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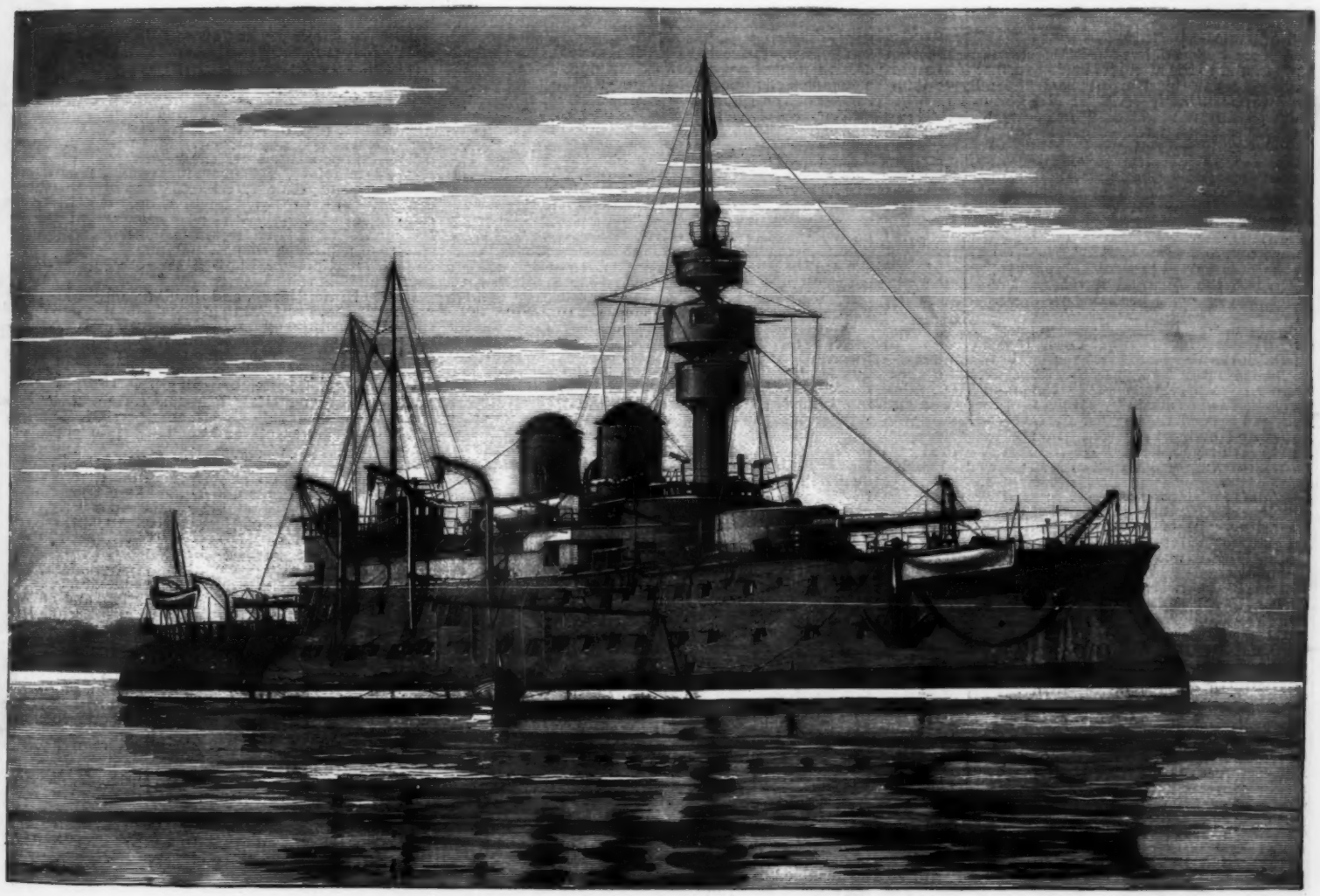
THE FRENCH BATTLESHIP BOUVINES.

WE publish an engraving from the Engineer, London, of the small French battleship Bouvines, which was launched in 1892, and is now completed. Our cotemporary says she is one of a group of four war vessels originally intended to have been built upon the design of a modified Furieuse, viz., the Jemmapes, Valmy, Bouvines, and Tréhouart. But in consequence of the serious disposition to instability which the Furieuse and Terrible displayed during maneuvers in an ordinary Mediterranean gale, the dimensions of the last two vessels were modified, the beam being increased 12 in., and the freeboard raised about 8 ft. forward, while, to compensate partially for the consequent elevation of the forward gun, the caliber of both of them in the main armament was reduced from 34 centimeters—13·4 in.—to 30 centimeters—11·8 in.

The principal dimensions, etc., of the Bouvines and Tréhouart are as follows, and they differ very slightly from those belonging to the other two vessels, except as regards the particulars aforesaid: Length at the water line, 284 ft.; beam, 58 ft. 8 in.; draught, 22 ft.; displacement, 6,610 tons; indicated horse power, 8,400; speed, 17 knots; coal capacity, 300 tons. An armored belt of steel extends from stem to stern 17¾ in. in thickness above and 10 in. in thickness below the water line, this being surmounted by an armored deck of steel 4 in. thick. The turrets for the main armament are oval, and armored with 14½ in. steel plates. They rest upon armored redoubts 12⅝ in. thick, built upon the armored deck.

The armament consists of two 11·8 in. guns, as before mentioned, eight 10 centimeter—4 in.—quick-firers, and fourteen smaller quick-firers and machine guns. The main armament is very powerful, the 30-centimeter gun being 45 ft. in length, and capable of piercing 35·7 in. of armor. The great length of the weapon is an obvious advantage. As will be seen by a glance at the engraving, it is capable of being fired in a horizontal line either direct ahead or direct astern without endangering the integrity of the deck or the structure of the ship; the muzzle projecting so far forward and aft as to clear them from the effect of "blast." Its height above the deck also necessarily conduces to this end, and gives additional gun command—a very important feature. The position of the eight 4 in. quick-firers is equally good. They are all upon the superstructure, so that when the scuttles are closed the hull of the vessel has no gun ports to attract observation and fire, while each gun is within a stout and capacious steel shield. Many of the smaller quick-firers are equally well placed within the shelter of the fighting tops, of which there are two independently of the conning tower, upon the single fighting mast. Four of the 10-centimeter quick-firers, as well as the guns of the main armament, can be trained axially ahead or astern at the same time. The position of the smaller quick-firers in the fighting tops is one of considerable security, and well thought out by the designers of the vessel, so long as the mast itself remains intact. Here the naval architects of France have adhered to their old policy of providing for "top fire," which proved so terribly destructive to both officers and upper deck men at Trafalgar and other actions of that period. We should be sorry to see the decks of our vessels encumbered with the towering monstrosities which rise, like the minarets of a mosque, from the Hoche and Magenta; but, after the experience of the unfortunate crews of the fighting tops in the recent naval actions between China and Japan, we confess that it would be satisfactory to know that some attention was being paid to the safety of the men who would have to occupy this position in the event of action with our own vessels. The shallow thinly plated cheese boxes, which contain, upon the Majestic class, no less than four 3 pounder Hotchkiss guns, would be cleared of their occupants in a few moments by the machine guns of the crews occupying the upper top of the Bouvines, while these last would be in comparative security, as they could not be seen.

The Bouvines, drawing only 22 ft. of water, could go in and out of estuaries which would be denied to the Royal Sovereign and Magnificent.



THE FRENCH BATTLESHIP BOUVINES.

THE EVOLUTION OF SMOKELESS POWDER.*

By ROBERT C. SCHUPPHAUS, Ph.D.

SMOKELESS explosives, of which guncotton and nitroglycerin are the most important representatives, have been known for a long time. The first discovery in this line was made by Braconnot in 1832, when he found that starch and similar bodies were rendered highly combustible through treatment with nitric acid. Six years later, Pelouze took the subject up and extended his researches to cotton, paper, and other vegetable substances. He found that the carbohydrates gained in weight when subjected to the action of nitric acid. Dumas pursued the subject further, and proposed to make nitramidine, as he called nitrocellulose made from paper, into cartridges. But the nitro bodies produced by these early investigators lacked stability and uniformity, and nothing came of these experiments. The foundation on which the structure of high explosives rests was laid in 1846 by Schonbein, who first succeeded in producing true guncotton, and who introduced the mixed acids bath, consisting of highly concentrated sulphuric and nitric acids. In his subsequent work he enjoyed the collaboration of Bottger, who had independently arrived at the same results. This fundamental discovery was quickly followed by Sobrero's preparation of nitroglycerin in 1847, accomplished in Pelouze's laboratory. The same year, Dr. Maynard, of Boston, discovered soluble guncotton, and applied its solution in a mixture of ether and alcohol, collodion, to the purposes of surgery. Nitroglycerin likewise found its first application in the United States, though not for its explosive properties, but as a medicine.

For convenience' sake, I make use of the traditional terms soluble and insoluble guncotton. We must not forget, however, that soluble pyroxylin exists in a great many varieties, and that the various grades employed in the arts, as, for instance, the manufacture of cellu-

* From the Journal of the Society of Chemical Industry.

loid, the production of varnishes, the preparation of collodion, of typical blasting gelatin, of smokeless powder, exhibit great differences in chemical composition and degree of solubility.

The insoluble variety, so called, is insoluble in a mixture of ether and alcohol and some other liquids, which either dissolve or soften the soluble grade, but is easily dissolved by acetone and compound ethers, such as the acetates of methyl, ethyl, and amyl, and is also soluble in nitrobenzene and nitrotoluene. To avoid tiresome repetitions, I will follow the course which the industrial applications of the soluble grade took, though I may thereby slightly disturb the chronological order. But it is the experience gained in these new industries which has proved indispensable to the manufacturer of modern smokeless powders. In 1851, Archer and Fry invented the collodion emulsion, and thereby vastly improved the art of photography. In 1860, Barnwell and Rollason proposed to use pyroxylin solutions as varnishes, and to make from such solution a multitude of useful articles. Soon after the subject was taken up by Alexander Parkes, of Birmingham, the inventor of Parkesine, and by Daniel Spill, of London, afterward manager of the Xylonite Company. In the United States, J. A. McClelland and John W. Hyatt were at work to utilize the valuable properties of soluble pyroxylin.

But an invention overshadowing all the others in importance was made by Daniel Spill in 1869, when he first produced a pyroxylin-camphor composition, plastic at about 75° C., by gelatinizing pyroxylin by means of a solution of camphor in commercial grain alcohol. As far as the chemical side is concerned, Daniel Spill must be hailed as the father of the celluloid industry, while to John W. Hyatt, at that time of Albany, N. Y., the greatest credit is due for devising suitable machinery for the intricate processes involved, for discerning the importance of pure materials, and for the perseverance which he exhibited under most adverse conditions. To-day, the world's daily production of celluloid amounts to 30,000 lb. To us the most important fact is, that there was no difficulty as far back as 1870 to fashion soluble pyroxylin into sheets, rods or tubes. Nor had it escaped observation that the gelatinized product was not nearly as explosive as the flocculent material.

After this short digression let us return to guncotton proper, and to the attempts made to utilize it as a propulsive agent. Sportsmen looked hopefully to it directly after its first production, and fibrous guncotton rammed into cases was used as a powder charge, but as is easily understood, with disastrous results. The feverish activity displayed in European countries to make and use guncotton gave way to a feeling of apathy after the numerous failures and frightful accidents which were due to faulty processes of manufacture and an insufficient knowledge of the new explosive. But carefully conducted experiments had convinced the Austrian General Von Lenk of the great promise of guncotton, and from 1849 to 1852 he worked indefatigably on improved processes of manufacture.

In 1853 the Austrian government erected works where the general's processes were carried out. Von Lenk recognized that it was necessary to decrease the rate of burning in order to utilize guncotton as a propelling powder; that, in other words, it was necessary to diminish the air spaces in the material to a minimum—to condense it, if I may use the term. What his successors have accomplished by the use of gelatinizing fluids he tried to attain by mechanical means, and to that end twisted and braided nitrated cotton yarn into ropes and cylindrical wicks. In the early sixties no less than thirty batteries of Austrian artillery fired guncotton cartridges from rifled cannon; they used smokeless powder.

Similar cartridges were tried in small arms, and the bursting charge of shells consisted of Von Lenk's plaited guncotton. The material was definitely abandoned in 1865, after two large magazines had exploded in 1862 and 1865 from unknown causes. Shortly afterward, Uchatius, another Austrian officer, tried to introduce nitro-starch into the service, but its lack of stability, as then prepared, and its physical properties unfitted it for the purpose. In the meantime the English government, to whom Von Lenk's process had been communicated, had instituted experiments on a large scale under the direction of Sir Frederick Abel. The same year that Von Lenk's labors were brought to such an unhappy conclusion, Abel published his process of pulping and compressing guncotton, which marked a new era in the history of this explosive.

This method permitted the manufacture of an absolutely stable article; and no higher testimony to its intrinsic worth is needed than the fact that it has remained the standard method of treatment of nitrated cotton all over the world, though in the nitration proper, in the apparatus employed, and in the restoration of spent acids great improvements have since been made.

At this time appeared the first semi-smokeless sporting powder of Col. Schultze, of the Prussian artillery, embodying an idea first propounded by Barnwell and Rollason in 1860, namely, to replace the carbon of ordinary powder by finely comminuted pyroxylin. Schultze was aided in his experiments by Captain Dittmar, of dualin fame, also of the Prussian artillery. The original Schultze powder consisted of a wood cut into grains, purified, nitrated, and finally impregnated with nitrate of potassium, or both the nitrates of potassium and barium. Dittmar subjected the wood to a peculiar heating process before nitration, and his powder is to this day manufactured by the American Wood Powder Company. Both these powders were tried in the United States in rifles, by government officials, as well as the testing station of a large ammunition firm, and found utterly worthless for that purpose. The Schultze powder of the present day is very much like the E. C. which is made from pulped guncotton and nitrates, and has been brought to its present state of perfection through the efforts of Messrs. Reid and Johnson. Both these inventors have profited by the experience of the celluloid manufacturers, and employ solvents of pyroxylin to harden the grains. But this powder belongs to a later date, the early eighties.

Messrs. Prentice & Sons, of Stowmarket, the first private manufacturers of guncotton, tried in 1866 to supply the wants of the sportsman in a different way. They made a cartridge of felt-like paper, composed of guncotton and ordinary cotton, produced from a mixture of the pulped materials, which found much favor. Later they made a pellet of slightly compressed guncotton, waterproofed by an India rubber varnish. These were not sufficiently uniform for military purposes. Abel produced similar ones which gave very promising results in a Martini-Henry rifle. From 1867–68 he experimented at Woolwich with cartridges built up from compressed guncotton fired from bronze field guns, but found little encouragement, though the results were ahead of those obtained with Von Lenk's cartridges. The time had not yet arrived when a powder of the highest power, which of its very nature involves the absence of smoke, had become an urgent necessity.

While these attempts were made in England to obtain an improved powder from guncotton, which was naturally smokeless, in France experiments were steadily going on with another material, picric acid, which also yielded powders comparatively free from smoke. Two powders, those of Designoile and Brugère, came to the front, the former consisting of picrate of potash, saltpeter and charcoal, the latter of picrate of ammonia and saltpeter. Brugère's powder especially gave excellent results in a Chassepot rifle. Smoke and residue left in the gun were greatly reduced. This powder was used experimentally in the French army up to the time that the mysterious Poudre B made its appearance, and was later superseded by the laminated guncotton powder of Vieille and Sarrau. Up to this time several inventions had been made which were to play an important part in the future rapid development of smokeless powders. As early as 1875 Daniel Spill had taken out a patent for the production of tubes for military and other purposes from soluble guncotton, and among other solvents for the material he mentions alcohol and ether and nitrobenzene. We have here the forerunner of Hiram Maxim's and of Anderson's guncotton cords, and of Prof. Munroe's indurite. The same year gave us Alfred Nobel's magnificent invention of explosive gelatin, the prototype of ballistite and cordite.

In 1882, as previously mentioned, Reid and Johnson obtained their patents for producing hard grained sporting powders. The French military authorities took early note of their results. The following year Wolff and Max von Forster, a former captain of engineers in the German army, patented a process for the manufacture of grains of compressed guncotton with hardened surfaces. The surface of the grains was gelatinized by dipping the grains in ethyl acetate, nitrobenzene, or similar solvents of guncotton. These grains were to be used as charges for shells and aerial torpedoes. Petri, Fallenstein and Lisch in 1884 brought out an explosive, the base of which consisted of guncotton dissolved in nitrobenzene. At this time conditions arose that made a powder of high power and free from smoke a necessity. A powder of the highest power must needs be one that is totally resolved into gaseous products—it must be smokeless. It had been recognized long before the days of smokeless powder that it was necessary to get rid of any solid residue of smoke to attain ideal results. Smokeless is a concomitant feature of high power, and vice versa.

The naval service needed a smokeless powder for the use of its secondary batteries to ward off the attacks of torpedo boats, and the infantry required an improved powder, if any further advance in the accuracy and range of its rifles was to be made. The caliber of the small arms of all armies has slowly, but surely, grown smaller and smaller. And for obvious reasons. A much more steady flight can be imparted to a projectile of smaller diameter and elongated form than to the old fashioned bullet. This new projectile being a good deal lighter, requires a much increased velocity of travel to maintain its energy, its striking force. The greater velocity means a flatter trajectory, an increased accuracy of fire. Black powder, of which only about one-third is converted into gaseous products, which have to project the other two-thirds as dead ballast, was not equal to the new task, especially in the reduced powder chamber. It had already proved unsatisfactory in the interesting struggle between armor and rifled cannon. The great improvements which Major Rodman and Doremus, of the United States, had made in the physical characteristics of black powder through their invention of prismatic powder had not been sufficient. Heidemann, of the Westphalian powder works, and Duttenhofer, of the Rottweil works, invented nearly simultaneously the brown powder, and brown prismatic is used to this very day in heavy ordnance, though smokeless powder is pressing it close. This brown powder contains more saltpeter, less sulphur and instead of the common carbon underburned charcoal, similar to the charbon roux of Violette, which he proposed in 1847 for sporting powders.

Gans conceived the idea in 1885 of producing an improved powder through the substitution of sulphur by nitrate of ammonium. By using a certain proportion of the latter in conjunction with charcoal and saltpeter he imagined to have produced a powder which would not absorb water, and in the explosion of which potassium amide would be formed. Such was, of course, not the case; the powder was far from smokeless, and it was hygroscopic. Heidemann modified Gans' formula, and produced a powder possessed of remarkable ballistic properties. It furnishes comparatively little smoke that speedily disperses, and is less hygroscopic that any nitrate of ammonium powder hitherto prepared. The pressures in the chamber are lower, along the bore of the gun higher than with brown powder. This behavior is similar to that of the smokeless powders with guncotton base. For use in machine guns this powder was sealed up. But even when confined it is subject to changes, due to uneven distribution of heat during storage, and consequently lacks uniformity. Though it must be regarded as the first successful attempt toward the production of a smokeless artillery powder, it cannot be considered adapted to the requirements of naval service.

At this time, in 1886, the poudre B of Vieille and Sarrau appears. It consisted principally of gelatinized guncotton in the shape of laminæ, probably combined with picric acid or a picrate, compounds which in the shape of poudre Brugère and Turpin's melinite had long been employed in the French service. Recalling to our minds what had been accomplished up to that time, we need not wonder that the other European powers experienced no difficulty in duplicating the French powder and improving on it. The rifle powders of the European armies of the present day, with the exception of the English, are laminated gelatinized guncotton, both the soluble and insoluble grades being used. The v. Forster, the Walsrode, the Troisdorf, the latest Wetteren. Rifleite, belong to this class. The same compound, produced in proportionately larger dimensions, has been tried in field guns, but with no flattering success, as far as experiments conducted at the Sandy Hook proving grounds indicate. Better results have been achieved with a powder issued by the French government for the proof of guns, but not used in actual service, the "poudre B. N." This is composed chiefly of soluble pyroxylin and nitrate of barium, and is a kind of condensed tonite, rolled or pressed into dense striated sheets. These are broken along the grooves into strips and packed in bundles to make up the cartridges. There is some smoke and considerable residue.

Alfred Nobel produced an entirely different artillery powder. It had long been known that explosive gelatin, especially when the percentage of pyroxylin was run up, possessed considerable propulsive power. Mixtures containing much more than the usual quantity of nitrocellulose, and even true guncotton in addition, had been prepared. The use of volatile solvents, though not required in the production of true gelatin, to promote gelatinization, was well known. Celluloid manufacturers had incorporated oils, resins, and similar bodies with their compounds to obtain certain results. Nobel himself produced in 1888 an explosive celluloid, to serve as material for the manufacture of a fuse both waterproof and burning under water. He dissolved in nitroglycerin one sixth of its weight of camphor and incorporated therewith one half its weight of nitrocellulose by mastication between warm rolls. A compound of similar composition was the first Nobel powder, and the one described in the United States patent of 1891 differs only in so far from it as it contains about equal parts of nitroglycerin and nitrocellulose. The presence of camphor, owing to its great volatility, was a serious drawback, and Nobel soon dispensed with it. His proposition to evaporate it by means of a current of warm air is clearly impracticable. An important advance was made in 1889, when it was found that nearly any quantity of suitable nitrocellulose, even in the wet state, could be gelatinized by means of nitroglycerin. This was accomplished by malaxation between heated rolls. It had been a common practice of the workmen in explosive works, at least in the United States, to surreptitiously add water to a batch of gelatin in the course of manufacture to hasten the gelatinizing process. This new Nobel powder containing a slight percentage of diphenylamin to secure its stability, and cut up into cubical grains, has given excellent results in cannon. Powders of similar composition, but with a reduced amount of nitroglycerin, and cut up into smaller grains, were manufactured for rifles. The original Wetteren powder of Belgium was such a powder, though not manufactured after Nobel's latest process, but by means of a solvent—acetate of amyl in this case.

In 1888 Hiram Maxim, and simultaneously Anderson and Anderson, proposed to give definite shape to gelatinized guncotton by forcing it through holes or slits, and thus form it into strips, cords, and the like, which might be cut up. The grains thus produced, if composed of pure guncotton, are rather difficult to ignite, and certainly not suited to small arms. It is not expedient to force materials below a certain thickness through holes. If thin laminæ are desired, it is better to produce thin sheets and cut these into grains or strips.

Nobel's powder had been submitted to the English government, and had also become known to certain manufacturers of guns and ammunition, themselves bent upon evolving a suitable smokeless powder. Cordite, composed essentially of guncotton and nitroglycerin, united by means of a mutual solvent, and shaped into cylindrical cords, became first known in 1889. Abel and Dewar, Hiram Maxim and Hudson Maxim, of New York, dispute the priority of the invention. Abel and Dewar preferred to use true guncotton, and added tannin to the mixture as a restraining agent, while Hiram Maxim employed castor oil for the same purpose. The cordite, fired at the present time in the large calibers in the English service, contains an addition of vaselin. Hudson Maxim's cordite for rifles, tried at the Springfield Arsenal early in 1890, consisted of about equal parts of military guncotton and nitroglycerin, with a slight percentage of castor oil and of carbonate of magnesium as a neutralizer.

The great claims made for Guttler's "Plastomenite," patented in Germany in 1889, do not seem to be justified, when its composition is considered, nor are they borne out by experience. It is made by dissolving nitrocarbohydrates, such as soluble nitrocellulose, in solid nitrohydrocarbons, dinitrobenzene for instance. I will only add that this process was known and described in the United States in 1882.

Schuckler's powder, which was patented in 1890, is made of nitrostarch, gelatinized by means of nitrobenzene. It has not been manufactured to any extent, and there is no reason why guncotton, stable, easily made and eminently adapted to the purpose, should be abandoned in favor of nitrostarch.

Kolf's powder may be passed by, as may be others made of guncotton, but not gelatinized, such as proposed by v. Brauk, v. Romocki, and Dr. Emmens' gelbite. Nor do the various chlorate of potassium mixtures deserve more than a passing notice. V. Brauk's original recipe calls for a mixture of carnauba wax and lycopodium in conjunction with the chlorate. Later he employs gum tragacanth, dammar, resin, and other substances. Schnebelin's powder, which attracted a good deal of attention some time ago, is made of starch, mixed with a little vegetable pith, and converted into a paste by the addition of a chlorate solution. This paste is rolled out, dried, and grained.

It was not before 1890 that the United States government took up the subject of smokeless powder. The first powder of domestic manufacture submitted was Hudson Maxim's cordite. Cut in lengths to fit the cartridge cases, it gave excellent results, both as regards pressures and velocities. The difficulty of loading was so great, however, that a shorter grain had to be selected, with a corresponding increase in the pressures, but even then giving results far better

than could be obtained with Walsrode. Wetteren, Dupont's modified Wetteren, Nobel, or B. N. The same year I submitted a rifle powder of a short cylindrical grain, made of gelatinized military guncotton combined with the nitrate of an organic base. Another variety consisted of a compressed mixture of soluble and insoluble guncotton, the former only being gelatinated. But the ignition with the primers then in use proved so difficult that I abandoned these powders in favor of a nitroglycerin composition, all the more readily as it was impossible to equal the records of the other nitroglycerin powders. This new powder consisted of a peculiar grade of soluble pyroxylin, nitroglycerin, and shellac. For various reasons I substituted dinitrobenzene for the latter. All my powders contained urea to guard their stability. This powder gave a somewhat better record than the Maxim, and was also fired with satisfactory results in the 8 inch B. L. rifle. I give these details because a certain other powder of very similar composition has been extensively advertised. The similarity is by no means accidental. To show how easy it is to invent, and how dangerous a little knowledge is, I quote from the specification:

"Gunpowder, consisting of guncotton, nitroglycerin, lycopodium, and a neutralizer of free acid, such as urea crystals or dinitrobenzol." The equivalence of urea and dinitrobenzene had not been suspected up to October 24, 1893, the date of the patent in question.

The Ordnance Bureau of the United States Navy made extensive experiments with Prof. Munroe's indurite. The method of manufacture consisted in preparing guncotton of uniformly high nitration, converting this into a colloid by means of nitrobenzene, shaping this colloid into cylinders or tubes, and hardening these by the well known process of steaming. Guncotton, as first manufactured, was subjected to extraction with suitable solvents to free it from the lower grades. There are no difficulties to obtain a high and uniform nitration on a manufacturing scale by easier means. The choice of the gelatinizing agent does not seem especially fortunate. Though the firing tests with individual samples were very favorable, there seemed to be some difficulty in duplicating results. The ignition, too, is very difficult. At any rate, the navy has abandoned this powder, and is now conducting experiments with a powder practically identical with the French B. N. Insoluble guncotton has been substituted for the soluble, with a corresponding decrease in the quantity of nitrate of barium incorporated with the guncotton.

The Peyton powder, manufactured by the California Powder Works, contains, in addition to guncotton and nitroglycerin, ammonium picrate and apparently some carbon. It has given satisfactory ballistic results in the 0·30 caliber rifle and in the 3·2 field gun. As much as the examination of a couple of grains can show, the powder seems to be prepared by making a dough-like mass of the guncotton and nitroglycerin, incorporating the picrate with it, and then moulding the mixture. The incorporation is not thorough, small yellow lumps showing everywhere.

Two years ago Mr. Hudson Maxim and myself began experiments looking toward the throwing of aerial torpedoes by means of powder. In the course of our investigations, we developed a powder which is admirably adapted to artillery use, and has been successfully fired in field guns and in the heavy coast-defense rifles. The Maxim-Schupphaus cannon powder is a colloid, nearly all guncotton in the shape of multiperforated cylinders. It is well understood that a smokeless powder should contain a minimum of nitroglycerin, not only on account of its volatility and the consequent changes in composition, but to minimize the erosive effect of the powder gases. The multiperforated grains burn with an increasing surface, which means that an ever-growing volume of gas is generated while the powder chamber is being enlarged through the travel of the projectile along the bore. In this way it has been possible to rival the records of typical nitroglycerin powders with a powder nearly all guncotton.

It remains for me to refer to the decided influence which the improved military powders have exercised on the sporting powders. There are now several brands on the market which are nothing but gelatinized guncotton. To this class belong the v. Forster powder, in thin flat or curled laminæ, the rough-edged Walsrode, the globular Dupont, produced by gelatinizing finely comminuted guncotton suspended in water by agitating it with a solvent insoluble in water, and the nitroid of the Maxim Powder and Torpedo Company. The improvement of the latter powder is in a large measure due to the indefatigable exertions of our able assistants, Messrs. Frederick McGahie, M.E., and Edwin Taylor. A new French sporting powder, invented by Mr. Bruneau, contains dichromate of ammonia.

The effect of this vast development on allied industries has been widespread. Special factories have been built to cleanse cotton waste for nitration, and great efforts are being made, more or less successful, to make suitable cellulose from wood. The production of nitric acid shows an enormous increase, and the commercial product is of a concentration and purity never attained heretofore. The manufacturers of sulphuric anhydride have found a new outlet for their product. Acetone plants of large capacity, furnishing a chemically pure article, have multiplied. The manufacturers of black powder machinery have been compelled to turn their attention to the new forms of apparatus.

The production of powder has forever passed out of the hands of the empiricist. More than ever will the destinies of nations depend on the skill and faithfulness of their mathematicians and chemists.

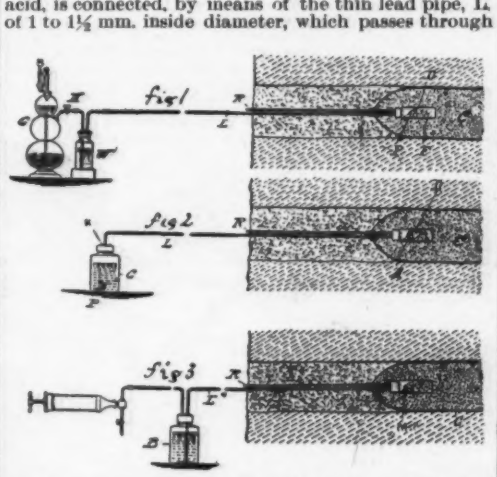
ROTH'S METHOD OF FIRING MINE SHOTS.*

THE object of this invention is to prevent any danger that may arise through the fuse used for igniting the charge, when blasting in fiery mines, causing explosions of air and fire damp in dangerous proportions. The essential feature of the method is to bring about, by means of a pipe containing a substance suitable for exerting such a chemical or physical effect on the explosive as to cause a heating, or even an actual detonation, sufficiently strong to determine the explosion of the cartridge contents. The pressure of the atmosphere or of any other gas may also be employed in such a manner that by compression, evacuation or absorption and capillary attraction, it will draw along certain fluids through a pipe to a special detonator, the contact with which will determine detonation. According as the explosion can or cannot be effected by one of the following substances being brought into contact with the introduced gaseous or fluid agents, the use of a detonator is or is not indicated. If, therefore, the introduced gases or liquids do not react upon the detonator or explosive, some substance must be introduced which will so react upon one of them.

The method hitherto generally adopted for igniting can be varied in many ways, both as regards the selection of the substances and also the mechanical power used for acting upon them: but the following is the most typical application:

The cartridge, C, Fig. 1, which may consist of any of the high explosives, such as dynamite, roburite or guncotton, contains the fulminate of mercury detonator, D, the front end of which is filled up, over the fulminate, F, with fine dry peroxide of lead, P, for about one-third of the space left in front of the fulminate. At the peroxide terminates a conducting pipe, L, made of thin lead, India rubber or papier-maché (sufficiently long to insure safety to the shot firer), leading from the gas-generating apparatus, G, which is divided into compartments, as shown in the engraving, charged, one with diluted sulphuric acid and the other with sub-sulphate of soda. If now the cock, H, of the latter be opened, the two substances, reacting upon one another, will generate sulphurous acid. For being completely freed from moisture, this substance passes through the wash bottle, W, which contains concentrated sulphuric acid; forces out from the detonator, D, the atmospheric air, which may pass away into the open air through a millimeter channel left in the upper portion of the hole, or tamping, or by means of a special papier-maché pipe, R: and by the formation of sulphate of lead heats the superoxide of lead, whereby the detonation of the fulminate and the detonation is transmitted to the explosive.

The glass jar, G, Fig. 2, filled about half full with 10 to 15 cubic centimeters of concentrated oxymuriatic acid, is connected, by means of the thin lead pipe, L, of 1 to 1½ mm. inside diameter, which passes through



the stopper, K, and nearly to the bottom of the jar, with the cartridge, C, in the shot hole, and its detonator, D, that contains, in the front end, which is free from detonating substance, powdered metallic antimony, A. In order to determine an explosion, a "pill," P, consisting of permanganate of potash or other salt evolved from chlorous acid, and covered with a more or less thick coating of zinc oxide, or other substance that evolves no gas when brought into contact with acid, is introduced into the inside of the jar, G, which is afterward made tight by the stopper, K, with the flexible lead pipe, L.

So soon as muriatic acid and permanganate of potash or the substances that may be constituted by them come into contact with one another, chlorine is evolved, which, conducted through the lead pipe, L, on to the metallic antimony, unites with it, while producing flame and constituting chloride of antimony. The pipe or channel, R, serves to make a way out from the inside of the detonator through the chlorine for the expelled atmospheric air; but if the cartridge contain a free space, this precaution is superfluous.

The flame produced by the action of the chlorine on the metallic antimony fires the detonator, and, consequently, the whole charge. In order to allow sufficient time, between the introduction of the pill into the glass jar and the commencement of the chlorine disengagement, for the man firing the shot to reach a place of safety, it is necessary to coat, more or less thickly, the solid material giving out chlorine with a substance, like zinc oxide, which is soluble in muriatic acid without disturbing gas evolution. For a glass jar containing 15 cubic centimeters (nearly one cubic inch) of concentrated muriatic acid, pills are used, which, for a weight of 2 to 3 grammes of permanganate of potash, are covered with a zinc oxide coating 1 to 2 mm. thick.

By these means the acid may first, by dissolving the coating—that is, after a space of time depending upon the thickness—evolve chlorine from the substance used for its production. This method of carrying out the invention affords the possibility of determining the explosion within a given space of time, as is the case when safety fuse is used—only without its danger—and, indeed, with a length of pipe only exceeding by about 15 cm. (6 in.) the distance between the mouth of the shot hole and the place occupied by the cartridge.

In the same manner as the sulphuric acid and chlorine or lead peroxide and metallic antimony above mentioned, other reacting substances may be used—for instance, as one of them, hydrogen, and as the other, platinum sponge or platinized asbestos. It may here be pointed out that the necessary specific gases for the ignition of the separate solid or liquid substances may also be stored in gasholders, or in a compressed form, inclosed in iron cylinders, and led through a long special pipe to the detonator or cartridge, the contents of which are to be fired.

As an example of the manner in which fluid and solid substances may determine an explosion, the following arrangement may be adopted.

A glass jar, like that shown in Fig. 2, or in place of it a lead receptacle, of about 1½ cm. (½ in.) inside diameter, and 7 to 8 cm. (mean 3 in.) long, contains about 10 cubic centimeters (0·6 cubic inch) of concentrated sulphuric acid. Into the latter dips, nearly to the bottom, a lead pipe, of 1 mm. inside diameter, leading to the inside of the cartridge that is introduced into the shot hole, and terminating—concurrently with another similar pipe (as in the former case above mentioned) for taking off the air from the inside of the cartridge—at a mixture of potash, chlorate and sugar—in the proportion of three parts potash chlorate to one part of sugar—occupying the place of the antimony in the former case. No detonator is required if the charge consists of black powder, as is the presumption in all the cases hitherto mentioned. The mixture of potash chlorate and sugar therefore assuming the form of a long cylinder several millimeters thick, or loose, merely contained in a paper case, reaches directly into the powder. If now a sufficiently large "pill," consisting of potash bicarbonate, be thrown into the sulphuric acid receptacle, it will generate carbonic acid, which, pressing upon the sulphuric acid, will force it through the pipe, into the explosive igniter of the cartridge.

If it be desired to employ a ready prepared gas for the mechanical introduction of the sulphuric acid into the cartridge charged into the shot hole, a hand-worked air pump, a pair of bellows, or a cylinder containing compressed air or carbonic acid, must be added to the arrangement, in the manner shown by Fig. 3. The sulphuric acid is forced, by introduction of gas, into the pipe leading to the cartridge, where it acts upon the explosive mixture in the front end, after the contained air is expelled by the exit pipe or channel.

A variation of this method consists in connecting the air pump or bellows with the exit pipe, for producing a vacuum in the detonating chamber of the cartridge, so that the sulphuric acid from the glass jar, connected only with the chamber, enters it to supply the vacuum and thus brings about the explosion in the same manner.

The possibility of applying to the present invention the capability of a fluid to absorb gas, in connection with the capillary attraction of hard but porous substances, may be proved by the following proceeding: A pipe of 1½ to 2 mm. inside diameter is filled with well calcined charcoal ground to ¼ mm. grains, care being taken that between the calcination and the filling of the pipe the smallest possible time shall elapse. The pipe with its contents is exposed for about half an hour to a temperature of at least 200° Cent., after which it is bent into the form of a circle, and a current of dry ammoniacal gas passed through. After the pipe has become cold, and while the current of ammonia is still passing through it, both ends are closed tightly. If now such a prepared pipe (the contents of which, because closed from the air, will remain unchanged for a long time) be brought into use, one end, which must, of course, only be opened at the very moment of the application, is put into airtight communication, by a piece of India-rubber pipe, with a case containing a mixture of potash chloride and sugar, the other end, also opened, dipping into an open glass jar containing concentrated sulphuric acid, in such a case the latter rises—being impelled by the absorption of the ammonia and the capillary attracting charcoal until the mixture ignites; and the flow is slower or quicker accordingly as the pipe is packed tightly or not so tightly with the powdered charcoal.

In the inventor's opinion the two following points must specially be borne in mind. The first is that, wherever a combustible gas having the character of hydrogen is used as the igniting medium, it must be led in metal pipes, of not more than 0·7 mm. inside diameter. With such a small conducting pipe explosion of a mixture of air and hydrogen cannot take place, which might, however, ensue if a pipe of more than 1 mm. diameter be employed, on the same principle as that on which the Davy safety lamp is founded. It is evident from this that the introduction of hydrogen can only be effected from a space deprived of air. The second point is that any number of shots may be fired simultaneously by means of a single jar; but it stands to reason that a separate pipe must be employed for each cartridge.

It would appear, from the first glance at the above figures, that the application of this invention in the confined underground workings of collieries would involve too great complication; and, indeed, the arrangements shown by Figs. 1 and 3 are only suitable for open workings, while that represented by Fig. 2, and the variation of it as described, may be used perfectly well in underground workings, as it only requires a 2 mm. pipe of the same length as the safety fuse now employed. The necessary acid, contained in a thick bottle, may be carried, with a special stopper, by the miner in his pocket. The channel for taking off the air of the cartridge charged into the shot hole may be formed by means of a wire, from 1 to 2 mm. diameter, inserted in the top of a (horizontal) hole, while it is being tamped, and afterward withdrawn. Finally, as regards the small jars, of which a man can carry fifty and more about with him, there is no more technical difficulty than occurs with the necessary cutting open lengthwise of the safety fuse at the end.

A successful experimental test was carried out with this method of firing shots in the underground workings of the Victoria Matthias Colliery, near Essen-an-der-Ruhr, Westphalia, four shot holes charged with westphalite being fired. In all cases the ignition took place at the end of the predetermined period of about three minutes. The method of carrying out the invention which was employed in this trial is preferred by Herr Roth to all the others above described so far as underground workings are concerned, on account of its safe and simple nature—viz., that it consists in the action of chlorine, generated from muriatic acid and permanganate of potash upon metallic antimony, which, together with fulminate of mercury, is contained in the detonator. The taking off the expelled air was effected in a simple manner by the following means: With the conducting pipe a second quite

* From communications to Glückauf, of Essen-an-der-Ruhr, by Herr Richard Cremer, mining engineer.—Colliery Guardian.

short piece of lead pipe was introduced into the detonator, which latter, in order to prevent a complete stopping up thereof, while the shot was being tamped, was bent round in a curve, and then by the introduction of a wire or pinning iron (Raumnadel) and drawing it out after the hole is tamped, a channel was formed for taking off the air. If the last named arrangement be not possible in the case of very wet holes, a second pipe, in addition to the chemical conducting pipe, must be used for taking off the air.

A great improvement has been introduced by the inventor in generating chlorine by the action of muriatic acid on permanganate of potash. As, on throwing the permanganate of potash into the muriatic acid an active disengagement of chlorine is effected, which might fire the shot sooner than expected, the "pill" is inclosed in a small piece of lead pipe, both ends of which are stopped with carbonate of zinc. The effect of this precaution is to prevent the permanganate of potash from acting before the zinc carbonate is dissolved. The space of time that must elapse before firing may also be regulated by the thickness of the zinc carbonate stopping.

A further and not unimportant advantage of this arrangement is that by the action of the muriatic acid on the zinc carbonate, carbonic acid is generated, which penetrates into the cartridge and expels any firedamp that may be contained in the air of the shot hole, and especially constitutes a suitable atmosphere highly impregnated with carbonic acid. With this stopping the time of the explosion may be determined within a few seconds; and it stands to reason that the mechanical preparation of the various parts would permit of still more accurate timing.

It may be stated, in conclusion, that, although the cost of this method of firing shots is at present slightly in excess of that by the so-called safety fuse, with ignition by means of steel and tinder, the slightly increased cost is more than compensated by the absence of danger from firedamp explosion.

EXCAVATOR USED ON THE NORTH SEA CANAL WORKS.

WE give an engraving of one of the types of excavators used on the North Sea Canal works, for which and the following particulars we are indebted to Engineering.

The excavators of the Lubecker Maschinenbau Gesellschaft were mostly of the type B of that firm, in which the structure rests on a broad track of three rails, and leaves a central opening for the wagons to run through. A few only of the excavators threw their spoil out behind in Couvreux fashion, the cars coming up to, but not passing through the excavator. The advantages of the newer arrangement are manifest. The great weight of the boiler and of the heavy gear is thrown on the further side, and acts as a counterbalance for the bucket ladder, while the lighter gear occupies a central position. The two rails on the near side impart further stability to the machines, which have steadily maintained their equilibrium on the Baltic Canal as they did near the Mersey, in spite of the much heavier work they had to perform in Holstein. Essentially the excavators are of the same construction as those employed on the Manchester Ship Canal. The passage through them is, however, higher, so that more powerful locomotives and higher wagons can be used. The width of the whole track does not exceed the customary limit. Of the twelve cast steel wheels, four pairs run on the 3 ft. track near the edge, the four others on the third rail. All have steel axles and elliptical springs, and the load is well balanced. An excavator which is to work at a depth of 20 ft. has twenty-five buckets of 0·3 cubic yard capacity, of which fifteen or seventeen tip per minute, from which an output of 280 cubic yards per hour may be calculated. The buckets, made of steel 0·28 in. and 0·35 in. in thickness, are riveted to the links of the chain, and provided with steel knife edges 7 in. by 0·6 in. The link pins, 1·6 in. in diameter, of steel, run in steel bushes, and are provided with wide heads which prevent turning. On the upper, not the cutting side, the chain is supported by six hard cast steel rollers. The tumblers are also cast steel; the upper tumbler is made in two parts, the lower rests in adjustable bearings. The ladder girder is composed of two U-irons, 1 ft. in height, with cross and diagonal bracings of angles and bars. Both the lifting chairs and the ladder are fitted with spiral springs, of which the latter has twelve near its upper pivot. A frame in which the ladder can slide, made of double angles and ties, prevents a lateral rocking of the ladder. The frame is pivoted to the main structure. The jib consists of U-iron and ties, strengthened by beams.

The motor is a pair of high pressure engines with cylinders 8 in. in diameter and 12 in. stroke, and at 240 revolutions it develops 45 horse power. A hydraulic friction coupling transmits the power from the crank and wheel gear over to the ladder. The pressure is obtained directly from the boiler by turning a three-way cock. This coupling yields, of course, if the excavator should meet with any great obstacle. The bucket ladder is raised by a system of wheels fitted with a conical disk gear, and is lowered by the brake. The driving mechanism of the machine comprises Gall chains and a conical friction gearing, and, further, a differential train of wheels between the near side and the off side axles, so that the machine can turn pretty sharp curves, in spite of its broad base. All the operating levers are grouped at the stand of the driver, who can survey the whole plant, ladder, wagons, engine, and boiler. A hinged shoot directs the soil into the one or the other of the wagons being loaded; this shoot has to be turned by one or two men.

The boiler is horizontal; it is fitted with tubes and a central grate of 414 square feet area, and works at a pressure of 100 lb. There are two water tanks of 350 gallons aggregate capacity, an injector, and a steam pump. The shell of the hut inclosing the engines is of corrugated iron, and rests on a wooden framing; this and the iron spiral staircases leading up to the stands of the driver and of the other men can be seen on our figure.

When the excavator is to work sideways, as in the fine bowlder clay shown in our illustration, some parts are modified after the fashion of dredgers, and the bucket chain runs backward, if we call the normal rotation that in which the cutting is done when the buckets are approaching the carriage. The buckets are fixed to shorter links, and are provided with shields connected to the next link forward, as with an almost horizontal ladder the soil is more apt to drop, because the buckets scoop a hollow in which they may overload themselves. The buckets, of 7·4 cubic feet, are a little smaller than those described above, stronger built, of 0·38 in., 0·31 in., and 0·24 in. iron, and fitted with one knife edge and two teeth.

The excavators scrape a layer of from 6 in. to 8 in. in thickness down to a depth of 20 ft., and leave a slightly curved batter, which requires very little finishing. Of the 50,000,000 cubic yards excavated in the dry—less than half the total excavation—the machines of the Lubeck Company raised 42·4 millions. According to Mr. Sympher, chief of the Holtenau section, the Lubecker excavator gave complete satisfaction in a soil in which a pickax could be only handled with difficulty. A train of thirty wagons, taking about 100 cubic yards altogether, was filled in less than half an hour; then followed an interval of about six minutes, during which another train was brought up, so that almost 200 cubic yards could be disposed of in an hour. In some soil these figures have been exceeded: in sand the excavator could barely travel fast enough for the delivery. For heavier ground the average was 160 cubic yards per hour.

ELECTRIC CARRIAGE WITH FULMEN ACCUMULATORS.

MR. JEANTAUD, whose electric carriage took part in the Paris-Bordeaux race, has sent us some data in regard to his vehicle that will prove of interest to our readers to know. It will be seen from the accompanying figures that it is provided with two parallel seats, each for two passengers, and a single seat behind, also for two passengers. The front is provided with a large circular dash board that supports a lamp containing three electric lights.

A box beneath the hind seats is arranged for the reception of the battery of accumulators. The wheels are of hickory. The hind ones are 1·4 meters in diameter and the front ones 1 meter. The load that they are designed to bear is distributed proportionally to the spokes, that is to say, 900 kilogrammes in front and 1,300 behind, say, in all, 2,200 kilogrammes.

The fore carriage, which has two pivots, assures an easy steering. The pieces that compose it, in consequence of a new arrangement, all work by traction.

Suspension in front is assured by two straight springs connected in the center and placed transversely under the box, which they support on the one hand, and which rest, on another hand, upon a cross brace near the pivots.

This arrangement secures great elasticity of suspension, while it at the same time lightens the traction. In fact, when one of the wheels meets with an obstacle, it is not obliged to lift the entire portion of the vehicle that it supports, since the frame oscillates around the central point of the attachment of the springs, the load is transferred to the other wheel, and the obstacle is thus surmounted without a jerk.

The frame of the box is wholly of flat welded steel, that presents itself edgewise under the load to be supported.

The axles have journals of 45 mm. in front and of 55 mm. behind. In consequence of an accident at the start from Paris, on the day of the race, the hind axle, strained in the straight portion, was constantly heated during the trip to such a degree as to necessitate halts every hour for cooling and lubricating. Upon the arrival it was found that the journal and hub of this axle were strongly gripped. It was to this accident that was due the retardation of the electric carriage in the Paris-Bordeaux race.

The stopwork consists of an instantaneous winding brake actuated by a circuit-breaking pedal placed under the foot of the driver, of a progressive brake maneuvered by means of two hand wheels at the sides of the front seat, and of a drag staff for cases of breakage of the chains upon gradients. These stoppage apparatus give an absolute security in the running and management of the carriage.

The mechanical part consists in the first place of a shaft carrying the differential gearing and actuating the wheels by means of two chains. Upon the differential are placed two wheels provided with teeth that permit of obtaining speeds of from 12 to 24 kilometers at the normal velocity of the motor.

A Bovet magnetic gearing was to have effected the change of direction, but, since the construction of this apparatus took a longer time than was anticipated, it became necessary at the last moment to substitute an ordinary gearing for it.

THE NORTH SEA CANAL—EXCAVATOR.

(Constructed by the Lubecker Maschinenbau Gesellschaft, Lubeck.)

The motor, which was devised and constructed by Mr. Rechniewski, engineer-in-chief of the Société Postel Vinay, gave remarkable results both in the brake tests and in the long trip of 600 kilometers that it furnished without breaking down. Thanks to its elasticity, its rendering exceeded 90 per cent. Strong and of careful and relatively light construction, it is designed to give, at its normal velocity, under a tension of 70 volts, nearly 7 horse power, corresponding to an intensity of about 70 amperes. This, in fact, is what the propulsion of the carriage necessitates at a speed of 24 kilometers on the level. Its weight is 225 kilogrammes.

The following are the renderings of the motor during the reception tests:

Couples.	Power developed. Horse powers.	Industrial rendering.
1	2·4	0·68
2	4·6	0 89
3	6·5	0·925
4	8·0	0·915
5	6·3	0 90
6	10·4	0·89

The elasticity of this motor is such that there may be required of it without its rendering being sensibly diminished or its perfect operation being affected, vigorous thrusts for ascending gradients. Under such circumstances, it easily develops from 14 to 15 horse power, say more than double that anticipated, without any heating of the parts or any spark at the brushes.

The test was many times repeated during a high speed ascent of some of the steep gradients on the Paris-Bordeaux route.

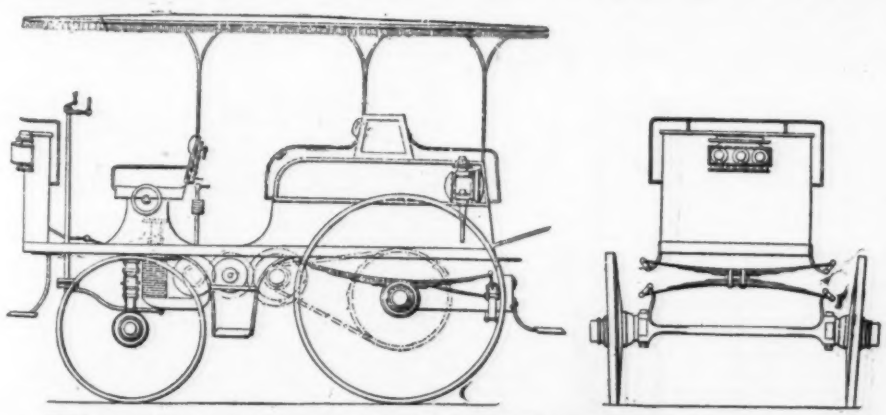
The electric apparatus were, with special view to the race, so arranged as to be maneuvered by a person occupying the second seat, so that the driver, seated in front, could devote himself exclusively to steering.

Mr. C. Brault occupied himself specially with the electric part of the apparatus, which consisted of: A reducer of 7 plots, permitting of different groupings; of a current reverser giving a backward and forward running; of an ingenious electric arrangement for regulating the running, and of a progressive or instantaneous brake that operated with great success.

The battery of accumulators that furnishes the energy to the motor consists of 38 elements of the type C 21 of the Société l'Accumulateur Fulmen, distributed through twelve boxes of three and four compartments. Each element, of a weight of 15 kilogrammes, presents a capacity of more than 300 amperes hour at the ordinary rate of discharge in 10 hours. At a discharge of 70 amperes, corresponding to a rate of nearly 5 amperes per kilogramme of plates, the capacity of the battery is still 210 amperes hour at a minimum, and consequently permits of running three hours at a speed of 24 kilometers on a level and upon a good road.

The discharge of 70 amperes was, moreover, frequently exceeded and often doubled. The accumulators at times were even submitted to efforts of 200 amperes of an appreciable duration, without the resulting lowering of the voltage preserving any character of permanence whatever. So, although such spurts corresponded to momentary discharges of more than 10 amperes per kilogramme of plates, the capacities anticipated at the time of the establishment of the relay stations along the route were experimentally verified.

It must be remembered, finally, that despite such great discharges, despite the repeated trips of certain batteries that were returned to Paris to be recharged and were shipped back again to Bordeaux, despite the hasty transshipments often operated by unskilful hands, and despite joltings on the way, no trace of alteration was detected in the Fulmen plates. There was no fall of active material, no projection of acid and no defective connections, and what is especially worthy of remark was the integral preservation of the stored up energy. Every battery, of a total weight of 850 kilogrammes, permitted of making a trip of from 40 to 70 kilometers, according to the profile of the route. The change of the boxes at the stations necessitated a stoppage of ten minutes, the connections being effected automatically by means of springs against which the boxes, filled with metallic plates, abutted.



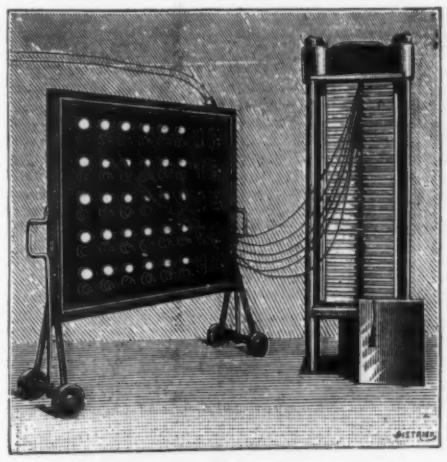
THE JEANTAUD ELECTRIC CARRIAGE, WITH FULMEN ACCUMULATORS.

It was not until the month of March, three months previous to the race, that the construction of the carriage, motor and accumulators was begun. This short interval permitted of but one trial of the vehicle before taking it to the Champ de Mars on the sixth of June, and aside from the continuous heating of the hind axle, none of the parts of the carriage nor the mechanical part of the motor necessitated any repair during the trip of 600 kilometers that the vehicle made.

In constructing this carriage and entering it in the Paris-Bordeaux race, it was Messrs. Jeantaud & Brault's object especially to prove by an absolute demonstration that electric propulsion was ready to enter the domain of practice. It may be said that such demonstration has now been made.—Revue Industrielle.

FINISHING FABRICS AND PAPER BY ELECTRICITY.

FOR finishing certain kinds of fabrics and also for obtaining effects of watering, diapering, etc., there is used a hydraulic press and heated plates between which the fabric or paper is placed. The heating of the plates is effected in a furnace. The inconvenience of this system is that during the work the plates become cool and the action obtained is not regular. The idea has occurred to Mr. Emile Claviez, of Chemnitz, to heat the plates by electricity and to thus establish



FINISHING PRESS HEATED BY ELECTRICITY.

an electric press. The arrangement devised by him is shown in the accompanying figure. The current coming from a dynamo reaches a distributor and is thence led to each of the plates of the press. Each of these is hollow and contains spirally arranged wires making a resistance to the current and effecting the heating. As may be seen, this arrangement is very simple. Moreover, the intensity of the heating may be regulated at will, and any desired effect be obtained. This is a novelty that will certainly interest many of our manufacturers.—La Nature.

THE ETHER.

THE ether, filling all space, is invisible, immaterial, imponderable, containing the elements of every known substance in the universe, organic and inorganic, in a like state of invisibility, immaterial, imponderable as itself in a condition of violent vibration pervading and entering through and through every substance in the universe, communicating to them the vibrations that reveal themselves to our consciousness as light, heat, electricity, motion, life. The ether, in passing through solutions of salts, imparts to them vibrations, giving polarity to their atoms and molecules, and arranging each in its respective form of crystallization. In its passage through organic substances it leaves in their substance the germs of life, giving each atom and molecule their distinct vibrations for increasing, developing, and assimilating the substances necessary for their development—life, out of itself, and out of their surroundings.

The ether, on entering substance, gives rise to attraction and repulsion—attraction of molecules in small bodies, attraction of gravitation in large bodies, by communicating to them its vibrations; every substance forming itself out of the ether thus obtains faculties that were not active in itself. The ether, pervading every substance in the universe, with its enormous rapidity of transit, 186,000 miles in a second, leaves some part of its substance that becomes material in that substance; likewise converts other parts to its own invisible, immaterial, imponderable state of existence and carries them into its mysterious laboratory; which is proved by the characteristic smell every object gives out in its surroundings, so that a blind man can distinguish the different metals, as iron, copper, zinc, silver, gold—the one from the other by the smell each has. Here we have one very slight example how material substance can be so diluted as to defy the analytical chemist to certify its existence. If nebulæ condense in space out of the ether, their substance must have been in the ether; where else could the ether have obtained it, except where it was to be found, in suns, planets, and other bodies? Everything in the universe is in a continual endless state of transition, transformation from one state of existence to another—has been, and will always be. If the ether contained substance as we understand the word, it would be luminous; whereas it brings to our astonished gaze the light of stars undiminished, that left them perhaps one hundred years ago. Herschel gave positive proof that it contains no substance capable of absorbing and reflecting light. Tyndall, in his lectures on light, referring to the ether, says, page 129: "By this time you have learned that the word light may be used in two different senses. It may mean the impression made upon consciousness or it may mean the physical agent which makes the impression. It is with the agent that we have to occupy ourselves at present. That agent is a substance which fills all space, and surrounds the atoms and molecules of bodies. To this interstellar and interatomic medium, definite mechanical properties are ascribed, and we deal with it in our reasonings and calculations as a body possessed of these properties. In mechanics we have the composition and resolution of forces and of motions, extending to the composition and resolution of vibrations. We treat the luminiferous ether [ether is not luminiferous] on mechanical principles, and, from the composition, resolution, and interference of its vibrations, we deduce all the phenomena displayed by crystals in polarized light."

Tyndall, page 31: "Having unraveled the interwoven constituents of white light, we have next to inquire what part the constitution so revealed enables this agent to play in nature. To it we owe all the phenomena of color, and yet not to it alone, for there must be a certain relationship between the ultimate particles of natural bodies and white light to enable them to extract from it the luxury of color. But the function of natural bodies is here selective, not creative. There is no color generated by any natural body whatever. Natural bodies have showered upon them, in the white of the sun, the sum total of all possible colors, and their action is limited to the sifting of that total, the appropriating from it of the colors which really belong to them and the rejecting of those which do not. It will fix this subject in your minds if I say that it is the portion of light which they reject, and not that which belongs to them, that gives bodies their colors."

To analyze by experiment a substance that is not a substance, invisible, imponderable, subject to none of the physical laws with which we are acquainted, appears an impossibility.

Eugene Turpin, in his work, La Formation des Mondes, page 1, writes: "Avant d'examiner les hypothèses plus ou moins fondées qui ont été produites sur l'origine des mondes, j'appellerai l'attention sur ce que l'on peut appeler une merveille, peut-être la plus grande merveille de la création, parce que'elle est invisible, insondable, inexplicable, incommensurable. Cette merveille, cet infini, plus grand que tous les mondes, plus incompréhensible encore que la formation de tous les soleils, c'est l'espace luimême."

In the number of the SCIENTIFIC AMERICAN of July 13 is a relation of a trial made to ascertain the manner of the passage of ether through bodies, from which it would appear that ether passes through all bodies, so that the amount of resistance it is subject to is unappreciable, and cannot be defined; that the ether, entering every body, communicates its vibrations to them, we have two proofs: in photography and in the scintillation of diamonds, observed under a microscope by an American, and published in the SCIENTIFIC AMERICAN, as follows:

"Every body is composed of a multitude of extremely, but not infinitely, small molecules," and it might be thought, says Sir R. Ball, according to a contributor in the Newcastle (England) Chronicle, that "in a solid, at all events, the little particles must be clustered together in a compact mass. But the truth is far more wonderful. Were the sensibility of our eyes increased so as to make them a few million times more powerful, it would be seen that the diamond atoms which form the perfect gem, when aggregated in sufficient myriads, are each in a condition of rapid movement of the most complex description. Each would be seen swinging to and fro with the utmost violence among the neighboring molecules, and quivering from the shocks it receives from the vehement encounters with other molecules, which occur millions of times in each second. The hardness and impenetrability so characteristic would, at first sight, seem to refute the supposition that it is no more than a cluster of rapidly moving particles; but the well known impenetrability of the gem arises from the fact that, when attempt is made to press a steel point into the stone, it fails because the rapidly moving molecules of the stone batter the metal with such extraordinary vehemence that they refuse to allow it to penetrate or even to mark the crystallized surface. When glass is cut with a diamond, the edge, which seems so hard, is really composed of rapidly moving atoms. The glass which is moving cuts also merely a mass of moving molecules, and what seems to happen is that, as the diamond is pressed forward, its several particles, by their superior vigor, drive the little particles of glass out of the way."

The frequent reference to light given out by diamonds in the "Arabian Nights" must have its origin in fact.

In photography, the vibrations proceeding from objects are concentrated by lenses, thrown on, and reflected, on a film sensitive to light, on which they impress the vibrations given by the objects where they came from, their activity being revealed when covered with an agent to which they communicate the vibrations, which by chemical affinity and harmony of vibrations render the before invisible image visible in all its most minute details.

In referring to atoms and molecules, I believe that they have no positive size, that all combinations only occur by harmony of vibrations, for however we magnify natural objects, their symmetry and forms of beauty increase in like proportions. I belive that chemical affinity is caused by rhythmical vibrations.

The question, if space existed before substance or the reverse, is futile, as neither ever was created, but

both have existed from all eternity. Space is substance, as it is impossible to conceive a nothing.

Turpin, in Formation des Mondes, page 2, writes: "Qu'est-ce que l'espace? Qu'est-ce que l'espace et d'où vient l'espace? Comment l'expliquer sans qu'il se présente, malgré nous, à notre pensés une limine, une fin? Les sphères immenses et innombrables qui peuplent cet espace ne sont rien, toutes matériélles qu'elles sont, toutes éclatantes de lumières, toutes rayonnantes feux colorès et éblouissants qu'elles nous paraissent, à côté de ce vide sans fond, de ces ténébres insondables, de cet espace sans chaleur, sans vie, sans lumière. Ce rien, ce néant précisement parce que ce n'est rien, parce que c'est le néant, est immenses, épouvantable et fait perdre la raison si on essaye de l'approfondir. Il n'existe rien de plus grand que ce néant, que ce rien qui ferait peur au plus braves s'ils s'en rendaient compte, et qui surpasse les limites de notre intelligence."

To these observations I reply that space has no limit, but is infinite; that it is not a "rien," a "néant," but is the birthplace of all the innumerable constellations floating in it.

The same author, page 58 states: "Il y a dans la nature, deux forces attractives probablement de même essence, mais absolument distinctes au point de vue de leur action."

In other words, it may be said that motion vibration is universal in the universe, that every object it contains is in a perpetual state of transformation from one state of existence to another, influenced by the forces of attraction and repulsion, these forces acting at great distances and at close; the one is called the attraction and repulsion of gravitation, the other, attraction and repulsion of molecules. These inherent forces are in proportion to the bulk of the bodies possessing them, and have been conferred to them indirectly by the ether. If, for instance, a nebula forming out of the ether has an area of some millions of millions of units in size, and then by attraction and contraction of its substance is condensed by several millions, this condensation would be sufficient to produce heat sufficient to form an incandescent sun. (See Grove, Correlation and Continuity; Mayer, Die Mechanik der Warme; Tyndall, Die Warme als eine Art der Bewegung, herausgegeben durch Helmholtz und G. Weideman.

All the discoveries that have been made (I ought to say observations) by pioneers of science tend to show that all the physical laws that we have become acquainted with are universal. To witness the confirmation of the theory we propound is impossible, as by their very tenor they would take in our estimation an incalculable length of time to be accomplished, and we are, in comparison, accorded only a few seconds for observation.

Motion, radiation, vibration, entering substance may effect the most wonderful changes, transformations, and become sound, heat, light, electricity, and each and every one of these effects can be transformed into the other. Helmholtz showed how vibration produced sound, and when augmented heat, and then light. Vibration produced by friction engenders electricity. Faraday converted magnetism to electricity; chemical affinity in batteries is converted into electricity; high pressure steam was changed by Armstrong into electricity. Woolen cloth, in certain stages of its manufacture, becomes highly charged with electricity. As the ether is the active agent of all these vibrations, why may it not also, in its incredible speed through most warm clouds, forming the cumulus, engender electricity, which clouds, becoming vast accumulators, when overcharged, relieve themselves by a flash of lightning? That after each flash, a deluge of rain falls and the temperature of the air is greatly diminished, would tend to show that the heat of the clouds that enabled them to keep vast quantities of rain in suspension has been converted into electricity and so disappears. When the writer, in a balloon ascent with Green, in 1847, was some 12,000 feet above the sea level, and above dense cumulus clouds, the heat of the direct rays of the sun was scorching, although the air was cold. He made some observation when on the summit of the Swiss Alps, the temperature of the air being below the freezing point in the shade.

Turpin writes, page 61: "La matière radiante l'ether, étant l'essence même des corps en général s'assimile d'une manière continue aux substances qu'elle rencontre et qu'elle pénétre, passant ainsi de l'impondérabilité á la ponderabilité. L'impossibilité de pondérer l'ether ou l'énergie, la matière radiante, en un mot, et l'absence de résistance qu'elle présente en tant que matière, á la marche des corps célestes, est la conséquences de cette faculté d'assimilation avec toutes les substances qu'elles quelles soient."

Weight is the attraction of the earth on substance; if the earth, sun, planets, were exactly balanced between two attractive forces acting in opposition to each other, the body between these two forces will have no weight—can, therefore, be suspended in the ether and revolve round the sun in its orbit without hindrance or friction, following for immense periods of time the force that was given it millions, millions, trillions, of centuries ago, which in eternity may be considered as quite a modern event. R. LE GRICE.

Bruxelles.

THE GAS CALORIMETER.

WE illustrate by the accompanying engravings a valuable addition to the instruments of a chemical laboratory, the testing room of large manufactories, and the office of those who are engaged in connection with gas engines. The performance of a gas engine cannot be properly stated without reference to the efficiency with which it converts heat-giving fuel into work.

Hitherto the heating or calorific value of combustible gases has generally been identified with their candle power; a correct determination of the former could, however, only be obtained by a difficult analysis, which an expert analyst would require several hours to complete. This cumbersome method has been sometimes used in scientific investigations, but for industrial purposes it is quite impracticable. We therefore find that the economy of gas engines is expressed in so many cubic feet of "16-candle power gas per brake horse power." In using this standard the fact is overlooked or has to be either ignored or allowed for that not only may the heating value of gases from different companies vary very much, although their photometric value may be practically the same, but also that gas taken from the same main, at intervals of only a few hours, is liable to vary as much as 20 per cent. Besides, if one quality of gas shows a higher candle power than another, it does not by any means follow that its heating value has increased in the same proportion.

Modern practice gives ample means of producing a gas of brilliant candle power, while its heating value may be very poor. Considering the great extension which the use of gas has experienced as an agent in heating and in producing motive power, an apparatus has become absolutely indispensable which will quickly show the heating value of any specimen of gas that may be used for such purposes.

The calorimeter we illustrate fulfills for the first time these conditions. The principle on which the apparatus acts is, that the heat generated by a flame is transmitted to a current of water, lowering at a constant rate, and measurements are taken: 1. Of the quantity of gas burned. 2. Of the quantity of water passed through the apparatus. 3. Of the difference in the temperature of the water on entering and on leaving the apparatus.

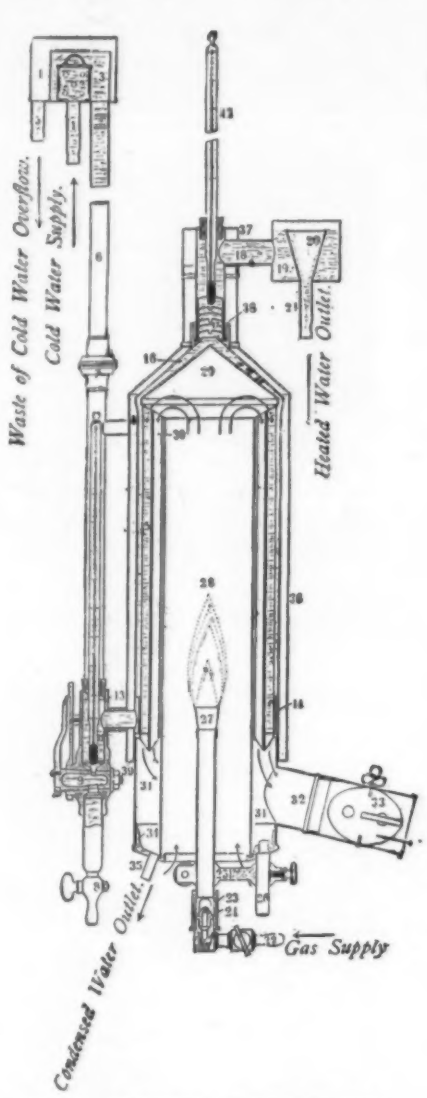


FIG. 1.—JUNKERS' CALORIMETER.

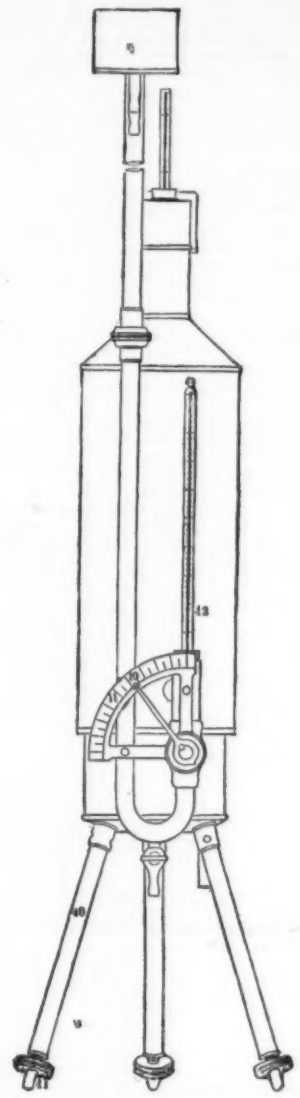


FIG. 2.—JUNKERS' CALORIMETER.

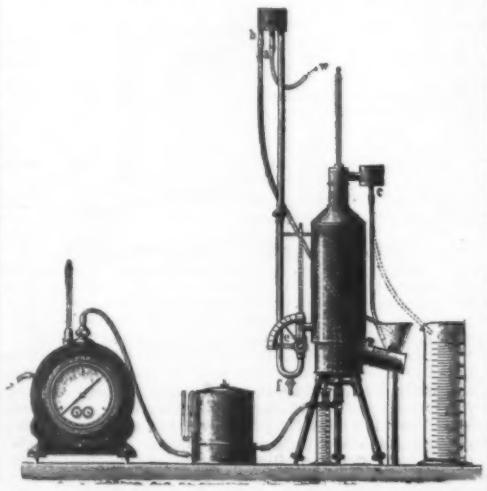


FIG. 3.—JUNKERS' GAS CALORIMETER, WITH METER AND GOVERNOR.

The construction and action of the calorimeter is exceedingly simple, and will be readily understood from the annexed illustrations. A flame, 28, Fig. 1, is introduced into a combustion chamber, formed by an annular copper vessel, the annular space being traversed by a great number of copper tubes, 30. Figs. 1 and 2, connecting the roof with the bottom chamber. The heated gases circulate inside the tubes from the top to the bottom, while a current of water ascends outside the tubes in the opposite direction. By means of this most suitable arrangement of counter currents all the heat produced by the flame is transferred to the water, and the spent gases escape through the throttle at atmospheric temperature.

The pressure of the water current is kept constant by two overflows, 3 and 20, and the quantity of water passing through the apparatus can be regulated by the stopcock, 9. A baffle plate, 14, surrounds the lower end of the tubes to insure an even distribution of the water, and in the neck of the apparatus, at 38, several disks with cross slots are arranged to insure an intimate mixture of the heated water before it reaches the thermometer. Provision is made to collect the water which is formed during the combustion of many gases in the annular space, 34, and to pass it into a measure glass through the tube, 35. To prevent radiation, the whole body of the apparatus is inclosed in an air jacket formed by a highly polished nickel plated copper cylinder. As the standard unit of heat generally used is the calorie, i. e., the amount of heat required to raise the temperature of 1 kilo.—1 liter—of water 1° C., this unit has been adopted in Junkers' calorimeter, which is therefore provided with two thermometers having the Centigrade scale, and admitting of readings of $\frac{1}{10}$° C. between zero and 50° C.

If British thermal units are required, the result in calories has only to be multiplied by the factor 4, more correctly 3·96828. The user must provide: 1. A water supply capable of passing from 1 to 3 liters per minute. 2. A correct experimental gas meter calibrated to pass $\frac{1}{10}$ cubic foot for one revolution of the large index pointer. 3. Two graduated measure glasses, one to contain 2 liters and another 100 cubic centimeters. It is further desirable to pass the gas through a reliable gas governor to insure even pressure during the tests. For very accurate results the temperature of the gas at the meter and that of the spent gases at the throttle may be observed and allowed for in the calculations; these may, however, be neglected in ordinary tests.

The calorimeter is placed as shown in Fig. 3, so that one operator can simultaneously observe the two thermometers of the entering and escaping water, the index of the gas meter and the measuring glasses. No draught of air must be permitted to strike the exhaust of the spent gas. The water supply tube is connected to the nipple, a, in the center of the upper container; the other nipple is provided with a waste tube to carry away the overflow. This overflow must be kept running while the readings are being taken, and in order to observe this, a short piece of glass tube may be inserted in the waste tube. The nipple, c, through which the heated water leaves the calorimeter, is connected by an India rubber pipe with the large measure glass, and the water must be there collected without splashing. The smaller measure glass is placed under the tube, d, to collect any condensed water. After the thermometers have been placed in position with their India

rubber plugs, the water supply is turned on by the cock, c, and the calorimeter filled with water until it begins to discharge at c.

For gases of high calorific power, e. g., illuminating gas, a burner is furnished with the calorimeter; for gases of lower power, e. g., hydrogen, carbonic oxide, Dowson's gas, etc., the plain metal tube serves as a burner.

The calorimeter has a maximum capacity of absorbing 2,500 calories per hour; the quantity of gas burned during the tests should therefore be regulated so that the flame produces only about 1,000 to 1,500 calories per hour. This will be the case with average qualities if the respective gases are burnt at the rate of the following quantities per hour:

Illuminating gas..... 4 to 8 cubic feet.
Hydrogen..... 8 to 16 cubic feet.
Dowson's gas. ... .16 to 32 cubic feet.

—The Engineer.

AGRICULTURAL CHEMISTRY.*

By H. W. WILEY, Chief of Division of Chemistry, United States Department of Agriculture.

AGRICULTURAL chemistry is a cosmopolitan science. It was founded by Liebig of immortal memory. Its early apostle in France was Boussingault; in England, Gilbert; in America, Johnson. It is presumably that science more nearly allied to the sustenance of human life, and thus lies nearer than any other to the heart, or perhaps the stomach of humanity. Its home is wherever a plant grows. Its devotees are found wherever a plowshare turns the soil. Its base lies in the study of the composition of the soil and the constitution of plants. Its superstructure rises high enough to touch the most abstruse questions of mineral and vegetable physiology and metabolism.

Turning from philosophy to facts, we find this science linked indissolubly with the greatest industry of the world. There is scarcely a field or a forest which has not felt the impress of its power. From the field its domain has extended to the factory, and the guidance and advice of the chemist are sought for the further preparation of foods and fabrics for the use of man.

It has also secured a place in the domain of public and advanced instruction, and even the conservatism of the great universities has yielded to agricultural chemistry a prominent place in the curriculum of studies. Both in this country and in Europe, hundreds of special schools and experiment stations are found devoted largely to the service of agricultural chemistry and its co-ordinate branches of science.

The art of fertilizing the fields, at first purely empirical, has become an exact science. The methods of saving and recovering waste fertilizing products at the present time renders many great industries possible which otherwise would have to yield to the fierce competition which every human endeavor has to meet in this end of the century.

Further than this the paternal efforts of agricultural chemistry extend and seek to recover from the mine and from the sea the elements of fertility apparently forever lost during the centuries that have passed.

The science of agricultural chemistry acknowledges without stint its indebtedness to the other fields of chemical work. In its very beginning it was the simple use of the principles of mineral analysis, applied to the soil and its products. By this means the parts of the plants which were derived directly from the soil were determined and the surprising fact was thus developed that nearly the whole of the vast product of vegetable growth is a free gift of Heaven and not chargeable to the soil. This was the point of union between agricultural chemistry and meteorology, and the basis of the science of meteorology applied to agriculture. The supply of carbon dioxide and water to the growing plant becomes thus a problem of the profoundest interest to agriculture, and the chemist and physicist have thus been led to study the great problems of precipitation, drainage and irrigation as affecting the products of the field. The best methods of disposing of an excess of rainfall, with the minimum loss of plant food due to percolation of water through the soil, are of no less importance. In connection with this, that treatment of the soil, by chemical and physical means, which will best prepare it to distribute the supply of moisture available to the advantage of the growing plant has been carefully studied.

Agricultural science has also drawn freely on the resources of organic chemistry. In agricultural products are presented to the student some of the most complicated as well as interesting organic compounds. In the growth of the plant are seen the wonderful resources of the vegetable cell in the way of chemical activity. The most renowned achievements of modern synthetic chemistry have consisted in the reproduction of some of the simpler forms of vegetable organic compounds. It will be admitted, without doubt, that the simple sugars are the least complicated of organic vegetable products, and these have been at last successfully made in the laboratory. The step from a hexose to a hexobiose seems indeed a short one, and yet it has not been taken. Only step by step must we expect the onward progress of synthesis until, for instance, a starch is reached. Yet, in the progress of organic synthetic chemistry already accomplished, great good has come. The exact chemical relations of the sugars to the aldehyds, ketones and polyatomic alcohols have been established and the bonds which unite the organic chemistry of man to that of Nature clearly distinguished.

On a former occasion, in an address to the Chemical Society, I have pointed out the futility of the expectation that synthetic organic chemistry will ever be able to take the place of agriculture, but the debt agriculture owes it is one of great and constantly increasing magnitude.

Not of less practical importance to agriculture has been the recent progress in our knowledge of that indefinite complex which has so long passed under the misnomer of "nitrogen-free extract." With the exception of the facts that it is not nitrogen-free and that it is not an extract, the name may do well enough. At least some agricultural chemists have an idea of what the term signifies, and to others it serves the purpose of the physician's malaria, permitting to designate, in a fairly mysterious way, a something of which nothing is known. The constitution of the greater part of this complex body is now known and the proportions of cellulose and of pentosans which it contains can be determined with a fair degree of definiteness. We should deem it a matter for congratulation to be assured that the day is fast approaching when the agricultural chemist will no longer be called on to determine forty per cent. or more of a cattle food "by difference."

In late years not only has organic chemistry helped us in the way of a better understanding of the composition of the carbohydrates, but it has also pointed out to us some of the main points in the constitution of those most valuable products, the vegetable proteids.

We are away behind our digestive organs in our understanding of these bodies and have been accustomed in practical work to place all proteid matter together in a single class. But there is no doubt of the fact that the vegetable proteids differ as much among themselves as those of animal origin, and at last the chemist is able to distinguish between them. Even if it should prove that there is little difference in their food value, yet it must be conceded that a knowledge of their structural differences, together with the several contents of nitrogen found therein, will prove in the end of the greatest advantage to the agricultural chemist.

The relations of agriculture to pedagogic chemistry have already been mentioned. In many of our public schools it is thought to be quite as important to teach the child something about the life of the field and the orchard as to drill him in the geography of Johora. How plants and animals grow is a theme which will one day be developed in every school in the land. Naturally, in agricultural colleges, the pedagogic side of agricultural chemistry receives due consideration, but, alas! with these institutions it is sometimes nomen et praeterea nihil. In these cases, agricultural chemistry must often give way to a heterochronistic psychology.

But, on the other hand, many of our universities have recognized the need of such instruction and have provided properly therefor. Merely material considerations should induce all our higher institutions of learning to provide for advanced instruction in agricultural chemistry; for just now there is, and for years to come there will be, a large demand for young men well trained in this direction. It will not be many years before it will be required of every well equipped university to provide liberally for the professional education of the young men who are to take charge of the agricultural colleges and experiment stations of the country.

In its relations to bacteriology, agricultural chemistry is also a debtor. In the life history of those minute vegetable organisms which exert so profound a chemical action on many bodies has been found the solution of the problem of those fermentations which prepare for use the nitrogenous foods of plants. The successive conversion of organized nitrogen into ammonia, nitrous and nitric acids is a process of the most vital importance to plant life. It is true that these activities were exerted for several millions of years without our knowing anything about them, and they would doubtless go on until the end of time if our knowledge of them should entirely cease and determine. Nevertheless, the value of what little knowledge we now possess seems almost the groundwork of scientific agriculture. The micro-organisms which nitrify organic nitrogenous compounds, as well as those which act in the opposite direction, viz., in reducing nitrates to a lower form of oxidation, are of the utmost importance to agricultural chemistry. It is not beyond the range of possibility that a barren field may be rendered fertile by securing conditions favorable to nitrification and then seeding the soil with a few active nitrifying ferments.

Quite true it is, already, that any scheme for an analysis of a soil which leaves out of consideration the determination of nitrifying activity is far from complete. The action of bacteria on the ripening of cream and of cheese is a matter of but little less importance. The fermentation of cream and of cheese is already as much of an art as the fermentation of malt in the manufacture of beer. In the curing of tobacco the same activity is discovered and the day is not far distant when commerce in high bred tobacco bacteria will be an established fact. In short, we may look forward to the day when the bacteria active in agriculture will be carefully cultivated and a bacterial herd book will be found along with those of the Jersey cow and the Norman horse. Agricultural chemistry makes demands on every science which can aid it in the production of food and in the advancement of rational agriculture.

But we may go still a step further and follow the crude food into the factory and the kitchen. From the knowledge of the action of ferments mentioned above the great art of food preservation has been created. The sterilization of food products and their preservation from the further action of destructive ferments is one of the practical developments of rational agricultural chemistry. This method of food preservation is infinitely preferable to that other simpler process which consists in adding to the food a substance which paralyzes the further action of micro-organisms. Happily, agricultural and analytical chemistry have provided a certain method of detecting chemicals thus used for food preservation.

The conversion of foods into appropriate digestive forms and the study of their nutritive power mark the final step in agricultural chemistry, in its control of food products. In this relation it comes into intimate contact with hygiene and animal physiology, thus almost completing the circle of intimate union with nearly all the leading sciences. Intimately associated with this branch of the subject is the control of the purity of the food itself and the detection of the adulteration to which it may be subjected.

The thoughts suggested in the foregoing pages are those that have come to me amid a multitude of distractions as those suited, at least in part, to meet the views of your presiding officer in asking me to introduce the theme of agricultural chemistry for discussion before the section. I now yield the floor for a more particular treatment of some of the branches of the subject.

* Abstract from a paper read before the American Association, Springfield, 1895.

THE PHYSICAL CONSTANTS OF ARGON.

WE have already dealt in these columns with the discovery and methods of preparation of atmospheric argon, and it remains now to examine the physical constants of the gas, and the important considerations deduced from them.

(1.) Boiling and Freezing Points.—That a liquid when it evaporates takes up heat from the surrounding bodies, that is, produces cold, is known to every one who has moistened his forehead with alcohol or ether. Furthermore, the easier the liquid evaporates, the more intense is the cold produced. It was by applying this principle that Olszewski, of Cracow, first liquefied argon. Ethylene gas, under a pressure of forty-five atmospheres and at a temperature of 1° C., readily becomes a mobile liquid. By promoting the evaporation of this liquid, by passing a current of air through it, the temperature sinks to —128° C., and at this temperature argon readily liquefied. This was under a pressure of thirty-eight atmospheres (570 pounds to the square inch); so in order to find the liquefying point under ordinary atmospheric pressure the argon was immersed in boiling liquid oxygen, which gives a temperature of —182·7° C. This, however, proved insufficient, showing that the boiling point of argon was lower than that of oxygen, and it was not until the oxygen was further cooled to —187° C. that the argon liquefied. On placing the liquid oxygen under the air pump to hasten the evaporation the temperature was reduced to —191° C., and under these circumstances the argon froze to a solid mass. The liquefying or boiling point of argon is thus —187° C., the freezing point —191° C. The freezing point is then 153° C. below the freezing point of mercury, and 133° C. below the greatest cold experienced in Arctic expeditions. The quantity of argon gas used in these experiments was 6·1 cu. in., which, on liquefying, became 7-1000 of a cubic inch, making argon, in the liquid state, 1·5 times heavier than water.

(2.) Density.—The density, or weightiness, of the gas is generally given in terms of hydrogen, which is the lightest gas known. The density of argon, obtained both by the magnesium and oxygen sparking methods, and in the hands of two different investigators, gave practically identical results. The value arrived at is 19·94, that is, the gas is 19·94 times the weight of hydrogen, bulk for bulk, measured at the same temperature and pressure.

(3.) Spectra of Argon.—Each substance in the universe when heated to a state of gaseous incandescence gives a series of lines in a spectroscope, characteristically its own. Argon gives no exception to this habit of the elements, but it differs from all others in that it gives two sharp-line spectra under different conditions. If an electric discharge of 27,600 volts potential be passed through a vacuum tube containing argon at 3-760 of the ordinary atmospheric pressure, the light from the discharge appears as a splendid orange red, and, on observation with the spectroscope, this light translates itself into eighty definite lines, coincident with the lines from no other substance at present known. If, now, the electro-motive force of the discharge be increased, and the pressure of the gas lessened, the color suddenly changes to a bright steel blue, and a different series of 119 lines appear in the spectrum, mostly in the blue end, and differing again in their position from those of other substances. Twenty-six lines are common to both spectra.

(4.) Ratio of Specific Heats.—The specific heat of a substance is that quantity of heat necessary to raise the temperature of a given mass of the substance one degree. In the case of a gas we have two specific heats, one at constant pressure and another at constant volume. The ratio of these two values would be a constant equal to 1·67 if the heat given to the gas were occupied entirely in moving the molecules from place to place. The observed values, however, fall far short of this, the only gases conforming to the theory being mercury at a high temperature, argon, and the more recently discovered helium. The special significance of this will be seen shortly.

Such are the chief physical constants of argon. We must now ask ourselves what information these constants will yield us in investigating the nature of the gas. First, shall we say that argon is an element or mixture of elements? That Olszewski found argon to possess a definite boiling point and freezing point speaks in favor of its oneness; that Crookes found it to possess two sharp line spectra proclaims it more forcibly still a mixture of elements. The deductions from these two facts appear to be contradictory; but we must remember that, although definite boiling and freezing points are the criteria of a pure substance, the amount of argon with which Olszewski had to deal was only 7-100 of a cu. in., a quantity so small that a minute percentage of impurity might easily escape detection, while it would with certainty be revealed by the far-seeing spectroscope. That no other substance but argon affords two sharp line spectra seems, though, decided evidence in favor of its complexity, and, as will be pointed out later, the existence of such a small quantity of impurity might well take argon out of its anomalous position in Mendelejeff's table of the elements. On the whole, the evidence seems in favor of its complexity. In corroboration of this conclusion, we may consider the fact that the atmosphere is just the place where we should expect to find all gaseous elements which, like argon, are chemically inert. As the earth cooled from an incandescent gaseous condition, "permanent" gases of this nature would find the atmosphere their only abiding place. "But," one might say, "why do we not find the recently discovered helium in the atmosphere, for it also is an inert gas?" We answer that, although helium is not found in the atmosphere of the earth, it is found in the atmosphere of the sun; and the reason for this has been recently afforded by the work of an Irish gentleman, Dr. Johnstone Stoney.

All gases are built up of ultimate particles called molecules. These molecules are in constant motion. By bombarding the sides of a vessel they cause what we know as gaseous pressure. Each little molecule has a free path and velocity of its own. Some of these velocities are almost inconceivably swift; thus an oxygen molecule travels at the rate of fifteen miles a

minute; water vapor at about twenty miles a minute; and hydrogen gas, which is the lightest known, at the amazing speed of a mile a second. This velocity may be increased seven times by collisions among the molecules themselves. Each molecule in the atmosphere, then, is in time bound to reach its maximum velocity, and we then have every oxygen molecule traveling at the rate of 1¾ miles a second, while a hydrogen molecule, if it could remain in the atmosphere, would fly seven miles a second. But it is not found in the atmosphere, and for this reason every body, whether it be a molecule, or the top of Vesuvius, if thrown away from the earth is pulled back again by the attractive force of gravity. The faster it goes, the longer it takes to return, and there finally comes a speed which the earth is just able to overcome through infinite time. Any velocity greater than this the earth would lose control over, and the body would wander through space until it fell under the sway of some other larger celestial object. This critical velocity, which the earth is just able to overcome through infinite time, is a little over six miles a second, and hydrogen molecules, therefore, whose velocity is greater than this, would not remain in the atmosphere, but would wander away, while the molecules of all gases possessing a velocity below six miles a second would, of course, remain in the air in the grasp of the earth's gravity. Now, the velocity of the argon molecule is greatly below the critical point, while that of helium is slightly above. The presence of argon and the absence of helium in the atmosphere are thus accounted for.

But we find helium in the sun's atmosphere, and naturally so, for the sun's mass is so immensely great that it is able to control the velocities of all known molecules. The fact that we have any helium whatever upon the earth is due simply to its slight power of combination.

Perhaps the most important data to obtain from any element are its atomic and molecular weights. The molecular weight of a gas is obtained by weighing 22·32 liters under standard conditions of temperature and pressure, because 22·32 liters of hydrogen weigh its molecular weight in grammes, and equal volumes of all gases contain equal numbers of molecules. Consequently, by weighing 22·32 liters of argon, under standard conditions, we shall obtain its molecular weight. This value is twice the density, or 39·88. The question now presents itself, "How many atoms are contained in the argon molecule, and what is its atomic weight?" and we are here confronted with an anomaly which has been brought up almost as an accusation against its discoverers.

The atom and the molecule of argon appear to be identical, that is, the atoms fly through space uncombined. This conclusion is arrived at on the following consideration. The ratio between the specific heat at constant volume and the specific heat at constant pressure of a gas falls short of the theoretical amount, for the reason that some of the heat given to the gas is occupied in doing intermolecular work, and this work done upon the constituent atoms of the molecule does not appear as temperature. If, however, the molecules were comprised of one atom, and this atom acted as a mathematical point, the possibility of intermolecular work would be denied, and the ratio would reach the theoretical limit, 1·67. Conversely, whenever we find this value for the ratio we are justified in considering the molecule of the substance monatomic.

The only gases whose ratio reaches the theoretical limit are mercury gas at a high temperature, argon, and the recently discovered helium. This conclusion is borne out in the case of argon by the fact that it possesses practically no combining power with other elements, just what we should expect if the atoms do not possess sufficient power to unite into aggregates or molecules. The atomic weight of argon, therefore, appears to be 39·88, provided, always, that it is a pure substance containing no other elements intermixed. This, however, we found doubtful from previous considerations; but we may say now that if argon be an elementary substance, free from all heavier impurity, Nature has given the chemist a slap in the face such as he has never before experienced: for the element with its present atomic weight will not fall properly into place in the periodic classification of the elements. The properties of the elements are periodic functions of their atomic weights. All the seventy some odd elements of the universe fall naturally and stringently into family groups, and these groups bear such relations to each other that from blank spaces in the table comprising them elements hitherto undiscovered and their properties may be predicted, and the prediction verified. Now, argon with an atomic weight of 39·88 would fall into a place already occupied, and among elements entirely alien to it in properties. The same thing holds for helium. They are both altogether de trop, from a classification point of view. If, however, argon possessed an atomic weight of about 38, it would fall gracefully into a vacant nook in the eighth column. The presence of a small quantity of some unknown gas would do away with this anomaly, and there is an additional reason to suspect the presence of this gas, for the spectra of argon and helium contain four prominent lines in common. This seems to signify the existence of a constituent common to both. Let us hope that it may be found. R. K. DUNCAN.

ABSORPTION BANDS OF ATMOSPHERIC OXYGEN.

DURING his recent visit to the Algerian Sahara, M. Janssen made, says Nature, some decisive observations concerning the absorption bands near the D line of the solar spectrum, supposed to be due to atmospheric oxygen. The object was to test whether these absorption bands correspond to those observed on transmitting white light through a tube containing condensed oxygen. In some previous experiments on this question, M. Janssen had obtained these bands by means of a tube 60 m. long, containing oxygen compressed up to 6 atmospheres. An account of the Sahara observations is given in the Comptes Rendus, together with a theoretical investigation concerning the equivalent height of the atmosphere. Starting with the remarkable law discovered by M. Janssen that the absorptive power of a gas is proportional to the thickness traversed and to the square of the density, the integration of the different layers of the atmosphere with their different densities gives 3,981 m. as the equivalent thickness for a vertical ray of light. But since the density of oxygen is only 0·208 of that of the atmosphere, this number must be multiplied by 0·043, the square of that density. This gives 172 m. as the equivalent thickness of the oxygen layer. This thickness, at a pressure of one atmosphere, would not be sufficient for showing the absorption bands, and this accounts for their absence when the sun is high in the heavens. But as the sun sets, the thickness of air traversed by its rays increases, and at an altitude of 4° the conditions are the same as those in the 60 m. tube at 6 atmospheres pressure. At this altitude they do in fact appear, and the excessive dryness of the desert air precludes the possibility of their being due to water vapor. Thus both the terrestrial origin of these oxygen bands and also the validity of Janssen's law of absorption have received a striking confirmation.

THE PHOTOGRAPHIC HALO.

ALL those who occupy themselves with photography have been more or less vexed to find upon a negative,

FIG. 1.—PHOTOGRAPH OF A CHURCH SCULPTURE.

otherwise irreproachable, and despite a very exact focusing, the annoying effects of a halo, which is shown by a flatness resulting from the encroachment of the lights upon the darks, even in those parts of the image in which the oppositions are the most marked.

The halo has especially proved the despair of photographers of the interior of buildings. It is easy to find examples of it produced by openings giving passage to light, and, in general, by all points brilliantly illuminated. We have before our eyes such a sanctuary of one of our finest cathedrals, in which it seems that a cloud of light is escaping from the large windows in all directions (Fig. 2).

As well known, the halo results principally from the

FIG. 2.—THE SAME, WITH A HALO.

reflection, upon the back of the plate, of the luminous rays that have not been completely arrested by the sensitized film, and which, arriving obliquely at various angles, have then deviated in another direction and returned to impress a second point of the sensitized film. The flatness thus produced is further extended by the fact that the luminous ray, having become diffused by its first passage through the opaline emulsion, is now a luminous pencil which acts from back to front upon the sensitized film, and forms a halo upon the surface where it falls, and which it impresses.

Several methods have been proposed for preventing such reflection of the light.

Backgrounds of velvet or paper, black, red or yellow, placed behind the sensitized plate for the purpose of absorbing the actinic rays, but slightly diminish the trouble, since the reflection of the light still takes place upon the stratum of air interposed.

These same surfaces, wet with the object of producing an optical contact with the glass, give better results, but, as the halo still manifests itself, plates have been made of successive layers thick enough to completely absorb the luminous rays, and the sensitiveness of which continues increasing. This process, however, is costly, and, without speaking of the greater difficulty of development, the halo reappears in cases of strong lights.

More success has been obtained by spreading over the back of the plates, before exposing them, layers of varnish or collodion, or even a solution of rubber in benzine colored red or yellow. In this case the halo is almost null.

Very recently it has been proposed to "ocher" the plates—a process that consists in covering their backs by means of a brush with a coating composed of—

Yellow or red ocher	100 parts.
Dextrine	50 "
Water	50 "
Glycerine	5 "

Negatives taken in a false light upon plates thus prepared show no perceptible trace of a halo; but, not to speak of the tedious manipulations to be performed, perfection has not yet been reached, at least theoretically, since a feeble halo may be produced.

But we have here, however, some notable improvements that may be useful to amateurs.—La Nature.

ANTIVENINE.

By Dr. J. G. MCPHERSON, F R.S.E.

IN the July number of Knowledge I communicated some of the results of Prof. Fraser's admirable experiments on snake poisons and their antidotes. The other day he laid before the Royal Society of Edinburgh some equally important results. He has continued the same line of experiment with increased success, and he can now see the very important boon his discovery will confer on the people of India.

His method is to ascertain the minimum lethal dose for an animal; to begin experimenting upon a similar animal with a smaller dose. After a short interval he increases this dose, until in time he can inject fifty times the minimum lethal dose into the animal's blood without producing any bad effects. This animal is immunized, and its blood serum, injected into another animal of the same size and weight, will prevent the action of snake poison when injected. Besides, if, in an animal which has had snake poison injected into its blood, a quantity of this immunized blood serum be injected within a reasonable time, the poison is antagonized, and is rendered innocuous. This immunized blood serum is called by its discoverer antivenine.

Prof. Fraser has now found that the blood serum of a rabbit, which had received thirty times the minimum lethal dose, was quite as effective in its antitoxic properties as that of a rabbit which had received fifty times the minimum lethal dose. The latter, however, will survive a much larger dose than the former. Still, for antivenine purposes, this is a saving in the very scarce snake poison.

The most important discovery was to be left for the experiments on the horse. So much poison was required to immunize a horse, that the professor had to defer his experiments until he procured from the Indian government a sufficient quantity. This he has secured. In February he commenced injecting a clean horse with one-fifth of the minimum lethal dose. The next injection of one-half the minimum lethal dose was given seven days later; then three-fourths of that quantity five days after this. He went on gradually increasing the dose in this way for four months and a half. The first injection caused general disturbance and rise of temperature, but the subsequent ones had no bad effect, except the local symptoms of cutaneous œdema and necrosis of small patches of skin at the point of injection. He obtained the blood serum from this immunized horse after the long interval of experiments by drawing off some from its jugular vein. He found that a hundredth and even a thousandth part of a cubic centimeter per kilogramme of animal was sufficient to prevent death from the minimum lethal dose of the venom. The antivenine obtained from the horse was found to be twice as powerful as that from the rabbit. The dose last given to the horse may have been fifteen times the minimum lethal dose, so that antivenine can evidently be obtained from the horse by administering that quantity of the poison. Although experiments may yet prove that more powerful antivenine might be desired, yet that obtained from the horse is quite powerful enough for counteracting the poison of snake bites in man.

Already a quantity of this antivenine is on its way to India for use there. Prof. Fraser has put it up in two forms, a liquid and a dry form. The dry state has an advantage over the other in more ways than one—it goes into less bulk, is practically indecomposable, and loses none of its antitoxic properties by being dried. On the other hand, some which was put up in the liquid form underwent decomposition, or at least became quite turbid in appearance, though at first quite clear. Now if that happens in our temperate climate, it would be much more likely to decompose in tropical countries. Accordingly the dry antivenine will ultimately be the exported product for use in India.

Prof. Fraser has observed a peculiar fact, viz., that dietary has an effect upon venom poisoning: for example, if a herbivorous animal be put upon flesh diet, the effect of venom upon it is much lessened. To prove this, he took a family of young white rats, and for seven weeks fed them entirely upon flesh food, except occasionally when a little vegetable food was given to keep them in good health. One of these rats had an injection of one and a half times the minimum lethal dose to commence with, and there was very little or no change produced by the poison. Another had twice the minimum lethal dose injected; it recovered after a short illness. The other rats died from ill health occasioned by the change of dietary.

By another set of experiments, Prof. Fraser has found that the deadly effects of serpent's venom is supposed to be due to its effect on the blood. Venom

is almost inert when introduced into the stomach or any other part of the alimentary canal. A cat was made to swallow one-fifth of the minimum lethal dose, then one-third, and then one-half, and so on, until on the one hundred and sixteenth day it received into the stomach at one time a dose eighty times larger than what would have killed a clean cat by injection —yet no observable disturbance was produced by these doses. To have carried this experiment any further would have required upward of a gramme of venom. This he could not afford with a rapidly diminishing supply. This cat, so far immunized by the stomach, was then given under the skin an injection of one and a half times the minimum lethal dose; and no bad effects were produced except merely local ones. In the curious case of a cat which was being immunized while pregnant, it was found that the kittens, after birth, also became immunized through the mother's milk. One of the kittens received a dose considerably above the minimum lethal dose and recovered.

Important evidence in favor of the administration of the venom into the animal's stomach, for the sake of having it immunized, has been obtained with white rats. One received by the stomach a thousand times the amount which would have been a minimum lethal dose when injected under the skin into the blood. Afterward, the same rat had twice the minimum lethal dose injected subcutaneously, and it became sleepy for a time, but soon recovered its hilarity. Accordingly, when snake's venom is introduced into the stomach it does not produce any active poisoning effects; but some of it seems to become absorbed into the animal's blood so as to assist in the immunization. This may account for the immunity from snake bites said to be enjoyed by some of the snake charmers of India, who eat the dried poison glands of the snakes.

Snakes themselves seem to have some substance in their blood which renders them impervious to the effects of the poison. This may probably be got from venom shed from the poison glands, and absorbed through the mucous surfaces of the mouth; or it may be absorbed by the blood vessels and lymphatics passing to and from the glands. In some cases it may be secured by serpents devouring other members of their tribe, thereby absorbing venom by the stomach.

Prof. Fraser has obtained a living venomous snake, and he intends to test its blood for antivenine; but as it has been shedding its skin since he received it, he has put off the experiments till the animal recovers its good health.

It is now within the region of certainty that at no distant date this indefatigable snake charmer of a scientific character will be able to send out to India sufficient quantities of dried antivenine from the immunized horse to be of inestimable service to those who are exposed to the bites of venomous snakes in that extensive country. The experiments, interesting and curious as they undoubtedly are to the ordinary reader, are of paramount importance to humanity; and Prof. Fraser's discovery is sufficient to give him a distinguished place among the advancers of medical research. Should he yet be able to discover the chemical constituents of the antivenine so as to manufacture it by chemicals, his success will be complete. All interested in the saving of life must wish him every success in his laudable undertaking.—Knowledge.

FACTS ABOUT TRICHINA SPIRALIS, THE PORK PARASITE.

By Professor JOHN MICHELS, late United States Department of Agriculture.

DURING the last four years all pork exported to Germany and France has been officially examined by the microscope to test the presence of trichinæ in the meat, a government certificate to that effect being necessary.

In May, 1891, by direction of Mr. Rusk, Secretary of Agriculture, I organized the first station at Chicago with forty microscopists, none of whom had used a microscope or seen a trichina. These had all to be trained to the use of the instrument and a knowledge of the examination of meat. Half of the number were young men, the remainder being women.

It was no easy task under such circumstances to organize the inspection, but after one week of preliminary training they were all in fairly good form to make a start to report officially.

I had the honor of organizing for the government similar stations at Milwaukee, Omaha, Kansas City and Boston, where in all cases women only were employed.

I now offer a few facts and figures obtained.* The first annual report issued by the United States Department of Agriculture placed the average number of the infected hogs for the entire country at 2 per cent. The local average is, however, far above this amount, as in the New England States the average is 14 per cent., Professor Mark, of Harvard, having informed me that he had arrived at this conclusion by actual inspection. Indiana has also a bad reputation for the large number of hogs infected with trichinæ, while I understand that in the Southern States the hogs are comparatively free from the parasite.

I can state as a fact that during the four years in which I had charge of the force inspecting pork not a day passed during that time without trichinæ being found by the assistant microscopists engaged in the work. I remember that as many as 46 hogs were discovered infected on one of these days, and from 15 to 20 hogs was quite an ordinary result of a day's work.

But taking the general average for the whole country as officially given by the Secretary Agriculture at 2 per cent., it is certain that eaters of raw or partly cooked pork run the risk of being infected with trichinæ at least once in every fift times they eat the meat of hogs.

The question arises, If there are so many trichinæ in pork, why are there not more numerous cases of trichinosis?

In reply I would state that there were occasional outbreaks of trichinosis terminating fatally during the time I was in charge of the work of inspection, and I have noticed reports of many cases in the newspapers, and I have personally investigated deaths due to this disease. The first of these cases was that of a man and his wife who died at St. Francis Hospital, of this city, in great agony. I examined with the microscope portions of the bodies of both these people after death and found immense numbers of trichinæ still alive and in the active migrating stage. I could watch the parasites forcing the fibers of the muscle apart, and if one imagines millions of these trichinæ, all in active motion, rending the fibers apart as they forced their way through the muscles all over the body, it is easy to understand why these two persons died from actual exhaustion, due to the frightful tortures which they endured.

I may here state that death from trichinosis is usually due to intense inflammation caused by the young brood of trichinæ boring their way through the walls of the intestines on their journey to the muscles. As this number of parasites may number 30,000,000 in one individual, acute inflammation may arise, which would prove fatal.

In the case of the St. Francis Hospital patients both

FIG. 1.—Shows trichina sexually mature after it has passed to body of host.

man and wife appear to have passed this stage in safety, for when they died the parasites had reached the muscles. If the sufferers could have withstood the intense agony but a short time, the trichinæ would have ceased to migrate and become stationary, when all pain would have ceased and all danger passed.

While I was in Boston, Mass., there was an outbreak of ten cases in the city, some of which proved fatal, and in Providence, R. I., a whole family was infected with trichinosis, and in this case boiled ham caused the trouble, which, however, must have been but partly cooked.

But according to the extent of trichinæ in hogs there should be more cases of death from trichinosis. What is the explanation?

Thorough cooking practically kills the parasite, and as pork is eaten cooked by the majority of people, the element of danger is avoided by this practice.

But the cooking must be thorough, as shown in the Providence, R. I., case, where the sufferers cooked their ham. The trichinæ, when they arrive at their final destination in the muscle, become encysted, that

a b

FIG. 2.—Female trichinæ, showing embryos in various stages of development.

is, they surround themselves with a cyst composed of mineral matter, such as lime, and this covering becomes calcified and hard and forms a great protection against heat for the parasite. It is clear, therefore, that they can only be killed by cooking, if such cooking is thorough. Rare or partly cooked pork is, therefore, dangerous food. Frankfurter sausages merely dipped in hot water, which is the usual custom, are not cooked sufficient to kill trichinæ, and fried pork sausages are too often raw in the center and should be cut open to be eaten with safety. The pernicious practice of eating raw pork in any form is to be avoided by all sensible persons, but it is unfortunately followed by those of German extraction and immigrants from other parts of Europe, and all cases of trichinosis have been traced to those who have this disgusting habit.

This brings me to the point. If people are eating pork every day in a raw state containing trichinæ, why do we not hear of more cases of trichinosis, and why are there comparatively so few deaths from this cause?

The answer is simple, and from my experience of many years it is clear to me that trichinosis is by no means a fatal complaint; if it were, the hogs would die, and thus reduce the number of those afflicted with the parasite. But they do not die, but continue in perfect health, the presence of these worms in immense numbers when encysted and dormant having apparently no effect whatever on the general health of the animal.

While in Boston engaged at the work of inspection I made a test of one case to solve this point. In this instance I had the carcass of a hog which was the worst instance of infection by trichinæ which came to my notice. The pillar of the diaphragm, tenderloin and

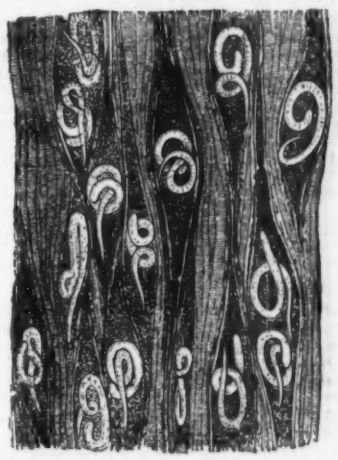


FIG. 3.—Showing invasion of trichinæ in muscle of hog. At this time they are always in the larval or second stage of development.

shoulder, which were the parts I first examined, were found to be so full of trichinæ as to be marvelous. Under the microscope they could be seen so closely packed together that in some portions of the picture presented one could not place the point of a pin between the cysts, some of which contained as many as seven worms instead of one, the usual number, so crowded were the parasites. I then had the carcass removed from the cooling room and microscopically examined all portions of the body and found trichinæ in every part. Yet the general condition of the body showed apparently good health; it was fat and well nourished and a naked eye inspection showed nothing to which objection could have been taken.

Thus trichinosis in hogs is not a fatal disease, and I believe it is only in rare cases that it causes death in man, then only where the trichinæ exist in very large numbers; say 50,000 or more to the ounce. In the great majority of infected hogs trichinæ are noticed thinly scattered in the muscle; if such meat is eaten, the result would probably cause irritation of the stomach, attended with pain and diarrhea, which would naturally cause many of the parasites to pass from the intestines, and the remainder, few in number, would bore their way through the intestines and reach the muscles, with pains and sensations which would probably be attributed to rheumatism, but with no serious harm.

Among the German population which eat raw ham, there are thousands thus permanently infected with encysted trichinæ who are not aware of the fact. Probably all those who constantly eat raw ham carry trichinæ in their bodies.

When, however, a raw ham is eaten which is loaded with trichinæ in immense numbers, the case is different. Supposing it had 50,000 trichinæ to the ounce, we would have 400,000 in a half a pound, resulting in probably forty to fifty millions of young trichinæ,

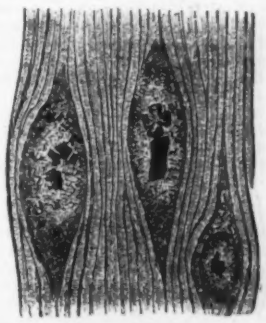


FIG. 4.—After remaining on the muscle for a long time the trichinæ die, change to a black color, and finally disintegrate, often forming crystals as shown.

ready to bore their way through the intestines and pass through the body of the victim, who would succumb to the intense inflammation caused by such a number of perforations.

The man and his wife who died in St. Francis Hospital were killed by eating raw chopped beef, into which the butcher threw a few pieces of pork, as he said, to give it a nice flavor. As Cobbold calculated that a single ounce of pork contained 50,000 trichinæ, it can be understood how easily a few small pieces may prove a fatal meal.

People who eat sausages are, however, eating raw pork every day. For nearly all sausages intended to be eaten without cooking contain pork which is virtually raw to all intents and purposes. Manufacturers of sausages have admitted this to me, and I can

* During my four years' experience in charge of this work.

state with certainty that bologna which is so very widely consumed contains pork which is uncooked, having been merely placed for a short time in a smoke chamber, which would not kill trichinæ or cook the meat. Servelat sausages also are largely composed of uncooked smoked ham. Here is a great element of danger tending to infect people with the parasite.

This explanation therefore shows clearly why there are so few fatal cases of trichinosis in proportion to the amount of infected meat consumed, and I trust that eaters of raw ham and pork may accept it as a caution, showing the inevitable result of such a habit, viz., their becoming the host of living trichinæ.

It has been the custom with pork packing houses (one firm at Milwaukee alone excepted) to place the bodies of infected hogs, rejected for the export trade, on the home market, thus increasing the danger attending the use of pork as food.

There is no reason for not subjecting the carcasses of all hogs to a microscopical inspection, which would not cost more than from one to two cents per carcass. If a large percentage of barrels of flour contained a poison, likely to lead to fatal results, would one or two cents be considered a useless outlay, or rather would not public opinion demand that such an examination be made to eliminate the danger before a food product in universal use should be placed on the market?

[FROM POPULAR ASTRONOMY.]

HISTORICAL EULOGY ON LAPLACE.

By BARON FOURIER.*

(Translated by T. J. J. See.)

GENTLEMEN, the name of Laplace has resounded in all parts of the world where the sciences are honored; but his memory could not receive a more appropriate homage than the unanimous tribute of admiration and regret of the illustrious body in whose labors and glories he has shared. He has consecrated his life to the study of the greatest objects which can occupy the human mind.

The wonders of the heavens, the profound questions of natural philosophy, the ingenious and subtile combinations of mathematical analysis, all the laws of the universe, have been presented to his mind for nearly sixty years, and his efforts have been crowned by immortal discoveries.

It was observed from his earliest studies that he was endowed with a prodigious memory; for him all intellectual occupations were easy. He rapidly acquired a very extensive knowledge of the ancient languages, and cultivated diverse branches in literature. Everything interests the born genius, everything can reveal it. His first successes were in theological studies; he treated with talent and extraordinary sagacity the most difficult points of controversy. We do not know by what fortunate circumstance Laplace passed from scholasticism to sublime geometry. This last science which admits of no division attracted and fixed his attention. From that time he abandoned himself without reserve to the impulses of his genius, and perceived clearly that a sojourn at the capital had become to him a necessity. D'Alembert was then enjoying all the splendor of his renown. It fell to his lot to inform the Court of Turin that its Royal Academy possessed a mathematician of the first order, Lagrange, who, by default of this noble recognition, had been compelled to remain long ignored. D'Alembert had announced to the King of Prussia that only one man in Europe could replace at Berlin the illustrious Euler, who, recalled by the Russian government, consented to return to St. Petersburg. I find, in the unpublished letters in possession of the Institute of France, the details of this glorious negotiation which fixed Lagrange in residence at Berlin. About the same time Laplace began that long career which he was soon to distinguish.

He presented himself to D'Alembert, preceded by numerous recommendations which were believed to be very powerful. But his attempts proved unsuccessful; he was not even introduced. Then he addressed to the one whose support he solicited a very remarkable letter on the general principles of mechanics, of which M. Laplace has several times shown me diverse fragments. It was impossible that so great a geometer as D'Alembert could fail to be struck by the singular profundity of this writing. The same day he summoned the author of the letter, and said to him, in his own words: "Sir, you see that I attach little importance to recommendations; you have no need for them; you have made yourself better known; this satisfies me; my support is due you."

A few days later he caused Laplace to be nominated Professor of Mathematics at the Military School of Paris. From this time on, devoted exclusively to the science which he had chosen, he gave to his work a fixed and never deviating direction; for imperturbable constancy of purpose has always been the principal trait of his genius. He touched already the known limits of mathematical analysis, he possessed all that was ingenious and powerful in this science at the time, and no one was more capable than he to extend its domain. He had solved a leading question of theoretical astronomy. He formed the project of consecrating his life to this sublime science; he was destined to perfect it, and able to comprehend it in all its extent. He meditated profoundly his glorious design; he has spent his whole life in accomplishing it with a perseverance which is perhaps unexampled in the history of the sciences.

The immensity of the subject flattered the just pride of his genius. He undertook to compose the Almagest of his age, a monument which he has left us under the name of the Mécanique Céleste; and his immortal work transcends that of Ptolemy as much as the analysis of the moderns surpasses the elements of Euclid. Time, which alone justly dispenses literary glory, which consigns to oblivion all contemporaneous mediocrities, perpetuates the memory of great works. These alone transmit to posterity the character of each century. Thus will the name of Laplace live through all ages. But I hasten to remark that enlightened and faithful history will not separate his memory from that of the other successors of Newton. It will associate the illustrious names of D'Alembert, of Clairaut, of Euler, of Lagrange and of Laplace. I restrict myself here to citing the great geometers whom the sciences have lost, and whose researches have had for a common aim the perfection of physical astronomy. To give a correct idea of their works it is necessary to compare them; but space obliges me to reserve a portion of this discussion for our memoirs.

Next to Euler, Lagrange has contributed most to the founding of mathematical analysis. In the writings of these two great geometers it has become a distinct science which alone of mathematical theories can be said to be completely and rigorously demonstrated. It alone among all these theories is sufficient in itself and throws light upon all the rest; to them it is so necessary that, deprived of its aid, they could very imperfectly exist.

Lagrange was born to invent and to extend all the sciences of analysis. In whatever condition fortune might have placed him, whether peasant or prince, he would have been a great geometer; he would necessarily have done it and without any effort; the same cannot be said of all who have excelled in this science, even in the first ranks. Had Lagrange been a contemporary of Archimedes and of Conon, he would have divided the glory of the most memorable discoveries. At Alexandria he would have been a rival of Diophantus.

The distinctive trait of his genius consists in the unity and grandeur of his views. He always fixes attention on an idea which is simple, just and very exalted. His principal work, the Mécanique Analytique, might be named the Mécanique Philosophique; for he reduced all the laws of equilibrium and of motion to a single principle; and what is not less admirable, he subjected them to a single analytical method of which he himself was the inventor. All his mathematical compositions are remarkable for symmetry of form, generality of method, and, if we may so speak, for perfection of analytical style.

Lagrange was no less a philosopher than a great

geometer. He proved this through the whole course of his life by the moderation of his desires, his immutable attachment to the general interests of humanity, by the noble simplicity of his manners and elevation of character, and finally by the fitness and profundity of his scientific works.

Laplace had received from nature all the force of genius which an immense enterprise could exact. Not only has he collected in his Almagest of the Eighteenth Century what the mathematical and physical sciences had already invented, and which constitute the foundation of astronomy; but he added to this science capital discoveries of his own which had escaped all of his predecessors.

He has solved, either by his own methods or by those whose principles Euler and Lagrange have pointed out, the most important and certainly the most difficult of all the problems which have been considered before him. His constancy triumphed over all obstacles. When his first efforts were not successful, he renewed them under the most ingenious and the most diverse forms.

Thus there was observed in the motion of the moon an acceleration whose cause could not be discovered. It had been held that this effect could arise from the resistance of the ethereal medium where the heavenly bodies move. If this were true, the same cause, affecting the course of the planets, would tend to change little by little the primitive order. These bodies would be incessantly disturbed in their courses and finally precipitated on the mass of the sun. It would be necessary that the creative power intervene anew to prevent or to repair the immense disorder which the lapse of time would produce.

This cosmological question is assuredly one of the greatest which the human intelligence can propose; to-day it is solved. The first researches of Laplace upon the invariability of the dimensions of the solar system and his explanation of the secular equation of the moon have led to this solution.

He first examined if the acceleration of the lunar motion could be explained by supposing that the action of gravity is not instantaneous, but subject to successive transmissions like light. From this point of view he could not discover the true cause. Finally a new research served his genius better. On March 19, 1787, he presented to the Academy of Sciences a clear solution, free from this capital difficulty. He proved very distinctly that the observed acceleration is a necessary effect of universal gravitation.

This great discovery subsequently cleared up the most important points of the system of the world. As a result the same theory shows that, if the action of gravitation upon the heavenly bodies is not instantaneous, we must suppose that it is propagated more than fifty million times faster than light, whose velocity is well known to be seventy thousand leagues per second. He further concluded from his theory of the moon's motion that the medium in which the heavenly bodies move offers to the course of the planets a resistance which is practically insensible; for this cause would effect especially the motion of the moon, and here the effect produced could not be observed.

The discussion of the motion of this body is rich in remarkable results. We conclude from it, for example, that the rotary motion of the earth on its axis is invariable. The length of the day has not changed one-hundredth part of a second during two thousand years. It is remarkable that an astronomer would have no need to leave his observatory to measure the distance from the earth to the sun. It suffices for him to observe closely the variation of the lunar motion; from this he could conclude the distance with certainty.

A consequence still more striking is that which relates to the figure of the earth; for even the form of the terrestrial globe is impressed upon certain inequalities of the course of the moon. These inequalities would not exist if the earth were perfectly spherical. We can determine the amount of terrestrial flattening by observation of the lunar motions alone and the results deduced from it agree with the actual measures yielded by the great geodetic voyages to the equator, in the northern regions, in India and numerous other countries. It is to Laplace above all others that we owe this astonishing perfection of modern theories.

I cannot here undertake to indicate his works one after another and the discoveries to which they have led.

This enumeration alone, however brief it might be, would exceed the limits which I was compelled to prescribe for myself. Besides his researches on the secular equation of the moon, and the no less difficult and no less important discovery of the long inequality of Jupiter and Saturn, we could cite his admirable theorems on the libration of Jupiter's satellites. We should mention his analytic treatment of the tides of the sea, and show the immense extension he has given this subject.

There is no important point of physical astronomy which was not for him an object of study and profound discussion; he subjected to calculation the greater part of the physical conditions which his predecessors had omitted. In the already very complex question of the form and the rotary motion of the earth, he considered the effect of the presence of water distributed between the continents, the compression of the interior layers and the secular diminution of the dimensions of the globe.

In this collection of researches we should notice especially those which relate to the stability of great phenomena: no object is more worthy of the meditation of philosophers. Thus we have recognized that the causes, either accidental or constant, which disturb the equilibrium of the oceans are subjected to limits which cannot be passed. The specific gravity of water being much less than that of the solid earth, it follows that the oscillations of the ocean are always confined between very narrow limits; which would not be the case if the liquid spread over the globe were of much greater density. In general, nature holds in reserve conservative and ever-present forces which act as soon as the trouble begins and augment in proportion as the disturbance is greater.

They quickly re-establish the accustomed order. We fin in all parts of the universe this preservative power. The forms of the great planetary orbits and their inclinations vary and oscillate in the course of ages; but these changes are limited. The principal dimensions are maintained and this immense assemblage of heavenly bodies oscillates about a mean position toward which it is always carried. Everything is adjusted for order, perpetuity and harmony.

In the primitive and liquid state of the terrestrial globe, the heaviest matter settled toward the center; and this condition has determined the stability of the sea.

Whatever may have been the physical cause of the formation of the planets, it imparted to all the bodies a projectile motion in a common direction about an immense globe; in this way the solar system has been rendered stable. The same effect is produced in the systems of satellites and of rings. Order is there maintained by the power of the central mass. Hence there is not, as Newton himself and Euler had suspected, an adventitious force which should one day repair or prevent the disturbance which time had wrought. This is the law of gravitation itself, which rules all, is sufficient for all, and maintains order and variety. Having proceeded once only from supreme wisdom, it has presided since the origin of time and renders all disorder impossible.

Newton and Euler did not yet recognize all the perfections of the universe. In general, whenever any doubt had arisen in regard to the exactness of the Newtonian law, and for the explanation of apparent irregularities, we have proposed the accession of a foreign cause, it has always happened, after a profound examination, that the original law has been verified. It explains to-day all known phenomena. The more precise the observations, the better do they conform to theory. Of all the great mathematicians, Laplace is the one who has penetrated most profoundly these great questions; he has, so to speak, settled them.

We cannot affirm that it was given to him to create an entirely new science, as did Archimedes and Galileo; to give to mathematical theories original and immensely extended principles, as did Descartes, Newton and Leibnitz; or like Newton to transfer for the first time to the heavens and to extend throughout the universe the terrestrial dynamics of Galileo; but Laplace was born to perfect all, to penetrate everything, to extend all limits, to solve what was believed to be insoluble.

* Delivered in the public session of the Royal Academy of Sciences, June 15, 1889.

He would have completed the science of the skies, if this science could be completed.

We find this same character in his researches on the analysis of probability, a science entirely modern and of immense extent, whose object, often misconceived, has given rise to the most erroneous interpretations, but whose applications will one day embrace the whole domain of human knowledge, a happy supplement to the imperfection of our nature. This art arose from a single trait of the clear and prolific genius of Pascal; it has been cultivated, since its origin, by Fermat and Huyghens. A philosophical geometer, John Bernouilli, was its principal founder.

A singularly happy discovery of Stirling, the researches of Euler, and above all an ingenious and important application due to Lagrange, have perfected this doctrine; it was cleared up by the objections of D'Alembert and by the philosophical views of Condorcet: Laplace collected and fixed its principles. It has become a new science of prodigious extent, subject to a single analytical method. Fruitful in ordinary applications, it will one day illuminate every branch of natural philosophy. If it is permissible to express here a personal opinion, we shall add that the solution of one of the principal problems, which the illustrious author has treated in the tenth chapter of his work, does not appear to be exact; and yet, considered in its totality, this work is one of the most precious monuments of his genius.

After having cited such brilliant discoveries, it would be useless to add that Laplace belonged to all the great academies of Europe. I could, and perhaps ought, to recall also the high political dignities with which he was clothed; but this enumeration would belong only indirectly to the object of this discourse. It is the great mathematician whose memory we celebrate. We have separated the immortal author of the Mécanique Céleste from all the accidental facts which concern neither his glory nor his genius.

Indeed, gentlemen, of what concern is it to posterity, who will have so many other details to forget, whether Laplace was at one time minister of a great nation? What concerns us most are the eternal truths he discovered; these are the immutable laws of the stability of the world, and not the rank which he occupied some years in the senate called conservator. What concerns us, gentlemen, perhaps still more than his discoveries, is the example which he set to all those to whom the sciences are dear; it is the spirit of this incomparable perseverance which has sustained, directed and crowned so many glorious efforts.

I shall therefore omit the accidental circumstances and, so to speak, fortuitous incidents, particulars which have no relation to the perfection of his works. But I may say that in the first body of the state, the memory of Laplace was celebrated by an eloquent and friendly voice, which important services rendered to the historical sciences, to letters and to the state have for a long time distinguished.* I shall recall especially that literary ceremony which attracted the attention of the capital. The French Academy, concurring in its recognition with the acclamations of the country, decided that it would acquire a new glory in crowning triumphs of eloquence and of political virtue.† At the same time it chose to return as a successor of Laplace an academician illustrious for more than a title, who united in literature, in history, in public administration, all the qualities of superiority.‡

Laplace enjoyed an advantage which fortune has not always accorded to great men. From his early youth he was deservedly appreciated by illustrious friends. We have in hand some leters, still unedited, which show us all the zeal with which D'Alembert introduced him to the military school of Paris, to prepare for him, if that were necessary, a better position at Berlin. President Bochard de Saron printed his first works. All the testimonials of friendship which were given him recall his great works and his great discoveries; but nothing could contribute more to the progress of all physical knowledge than his relations with the illustrious Lavoisier, whose name, consecrated in the history of the sciences, has become an enduring object of respect and grief.

These two celebrated men united their efforts. They undertook and carried out very extended researches for measuring one of the most important elements in the physical theory of heat. They made also, about the same time, a long series of experiments on the dilatation of solids. The works of Newton have made sufficiently known the value which this great mathematician attached to the special study of the physical sciences. Laplace is, of all his successors, the one who has made the greatest use of his experimental method; he was almost as great a physicist as a geometer. His researches on refraction, on capillarity, barometric measures, on static properties of electricity, velocity of sound, molecular actions, properties of gases, attest that nothing in the investigation of nature could be foreign to him. He always desired especially the perfection of instruments; he caused to be constructed, at his own expense, by a celebrated artisan, a very precise astronomical instrument, and has given it to the observatory of France.

All kinds of phenomena were perfectly known to him. He was connected by an old friendship with two celebrated physicists whose discoveries have thrown light on all the arts and all the theories of chemistry. History will connect the names of Berthollet and Chaptal with that of Laplace. He liked to associate with them, and their conferences have always had for an object and end the increase of knowledge most important and most difficult to acquire.

The gardens of Berthollet at his house d'Arcueil were not separated from those of Laplace. Great memories and great sorrows have distinguished this inclosure. It was here that Laplace received celebrated strangers, influential men, from whom the sciences had received or might expect benefactions, but especially those who were drawn by sincere zeal to the sanctuary of the sciences. Some were just commencing their careers, others would soon bring theirs to a close. He entertained them with extreme politeness. He even carried it so far that he allowed those who did not yet know of the full extent of his genius to believe that he might himself gain knowledge from their conversations.

In citing the mathematical works of Laplace we ought especially to point out the depth of his researches and the importance of his discoveries. His works are, moreover, distinguished by another quality which all readers have appreciated. I refer to the literary merits of his compositions. The work entitled Systeme du Monde is remarkable for elegant simplicity of style and for purity of language. There was no other example of this species of production; but we could form of it an approximate idea if we remember that it is possible to acquire a knowledge of the phenomena of the heavens in agreeable writings. The suppression of the signs required in the calculus cannot contribute to clearness or render the reading easier. The work is a perfectly regular exposition of the results of profound study; it is an ingenious résumé of the principal discoveries. The precision of style, the choice of methods, the grandeur of the subject, give a singular interest to this vast picture; but its real utility is to recall to geometers theorems whose demonstrations are known to them. Properly speaking, it is a condensation of the material of a mathematical treatise.

The purely historical works of Laplace have a different object. They present to geometers with admirable talent the march of the human mind in the discovery of the sciences. Consequently the most abstract theories have a beauty of expression which is all their own; the same thing is observed in several treatises of Descartes, in certain pages of Galileo, of Newton, and of Lagrange. The novelty of the views, the elevation of thought, their relations to the great objects of nature, charm and fill the mind. It suffices

MONUMENT TO BOUSSINGAULT.

that the style be pure and of a noble simplicity; such is the kind of literature which Laplace has chosen, and it is certain that he has here gained a place in the first rank. If he wrote the history of great astronomical discoveries, it became a model of elegance and of precision. No principal feature escaped him; his expression is neither obscure nor pretentious. All that he called great is great indeed; all that he omitted did not deserve to be cited.

M. Laplace preserved to a very advanced age that extraordinary memory which was the subject of remark in his earliest years: a precious gift which is not genius, but which serves it to acquire and retain. He never cultivated the fine arts, but he appreciated them. He was fond of Italian music and of the verses of Racine, and often took pleasure in reciting from memory various passages from this great poet. Paintings of Raphael ornamented his apartments. They were to be found by the side of the portraits of Descartes, of Francois Viète, of Newton, of Galileo and of Euler.

Laplace always had the habit of taking very light nourishment; he diminished the quantity more and more even to excess. His very delicate eyesight required continual precautions; but he managed to preserve it without alteration. These precautions for himself had but a single aim, that of reserving all his time and all his energy for intellectual work. He lived for the sciences; the sciences have rendered his memory eternal.

He contracted the habit of excessive concentration of thought, so injurious to the health, so necessary to profound study; and yet he underwent a sensible weakening only in the last two years of his life. At the commencement of the disease to which he succumbed there was noticed with alarm a symptom of delirium. The sciences occupied him still. He spoke with an unaccustomed ardor of the motions of the stars, and then of an experiment in physics, which he said was capital, announcing to the persons whom he believed to be present that he would soon entertain the academy with these questions. His strength left him little by little. His physician,* who merited all his confidence by superior talents and by the care which friendship alone could inspire, watched near his bed. M. Bouvard, his co-worker and friend, never left him for an instant. Surrounded by a beloved family, under the eyes of a wife whose devotion had aided in supporting the sorrows inseparable from life, whose amenities and graces had made known to him the prize of domestic happiness, he received from his son, M. Marquis de Laplace, express testimonials of the most touching devotion. He gave signs of gratitude for the repeated tokens of interest shown him by the King and the Dauphin. The persons who assisted at his last moments recalled to him the titles of his glory and his brilliant discoveries.

He answered: "That which we know is little, that of which we are ignorant is immense." This, at least, is, so far as we have been able to ascertain, the sense of his last words, which were spoken with difficulty. Moreover, we have often heard him express these thoughts and almost in the same terms. He passed away without pain. His supreme moment had arrived; the powerful spirit which had long animated him separated from the mortal envelope and returned to the skies.

The name of Laplace honors one of our provinces already prolific in great men, ancient Normandy.

He was born March 23, 1749; he died in his seventy-eighth year, May 5, 1827, at nine o'clock in the morning.

I shall recall to you, gentlemen, the sad gloom which spread over this palace like a cloud when the new fatality was announced. This was the day and the hour of your accustomed meeting. Each of you maintained a mournful silence; each felt the sad blow with which the sciences had been smitten. Every respect was shown in this place which he had so long occupied among you. One thought only was present; all other meditation had become impossible. You adjourned with a unanimous resolution, and this time only were your usual labors interrupted.

It is undoubtedly beautiful, it is glorious, it is worthy of a powerful nation, to ordain brilliant honors to the memory of its celebrated men. In the country of Newton the chiefs of state wished to have the mortal remains of this great man solemnly interred among the royal tombs. France and Europe have offered to the memory of Laplace an expression of their grief less showy doubtless, but perhaps more touching and more true.

He has received an unaccustomed homage; he received it from his own people, in the midst of a learned company which alone could appreciate all his genius. The voice of the weeping sciences has made itself audible in every country of the world where philosophy has penetrated. We have in hand much correspondence from all parts of Germany, England, Italy, New Holland, the English possessions in India, the two Americas; and we find everywhere the same sentiments of admiration and of regret. Certainly this universal lamentation of the sciences, so nobly and so freely expressed, has no less truth and splendor than the sepulchral pomp of Westminster.

Let me be permitted, before closing this discourse, to reproduce here a thought which presented itself when I recalled in this place the great discoveries of Herschel, but which is applicable still more directly to those of Laplace.

Your successors, gentlemen, will witness the accomplishment of the great phenomena whose laws he discovered. They will observe in the motions of the moon the changes which he predicted and of which he alone was able to assign the cause. The continual observation of Jupiter's satellites will perpetuate the memory of the inventor of the theorems which govern them in their courses. The great inequality of Jupiter and Saturn, running through their long periods, and giving to these bodies new situations, will recall without ceasing one of his most astonishing discoveries.

These are the titles of a true glory which nothing can extinguish. The spectacle of the heavens will be changed, but at these remote epochs the glory of the inventor will continue forever; the traces of his genius bear the seal of immortality.

I have presented to you, gentlemen, some characteristics of an illustrious life consecrated to the glory of the sciences; may your memories supplement my feeble language! May the voice of our country, may that of all humanity, rise to celebrate the benefactors of nations, the only homage worthy of those who have been able, like Laplace, to enlarge the domain of thought, and bear witness to man of the dignity of his being, by unveiling to our contemplation all the majesty of the heavens!

THE MONUMENT TO BOUSSINGAULT.

THE monument to Boussingault, erected in the courtyard of the Conservatoire des Arts et Metiers, situated on Saint Martin Street, was inaugurated on the seventh of July in the presence of numerous engineers and former pupils of the Conservatoire, who did honor to the author of "Economie Rurale," to the savant whose labors have marked the true advent of agricultural science, through the application of chemistry to agriculture and the study of phenomena relating thereto.

The subject of the monument, a work of the Sculptor Dalon, is Science advising the Husbandman. A young woman seated and simply clad in ample drapery personifies Science. In her left hand she holds a partly opened book that she has stopped reading in order to give directions to a husbandman who is leaning toward her, and to whom she points out with her forefinger a soil that is as yet unproductive, but which with her aid is going to be transformed and redeemed. At her feet are two retorts and a furnace, the usual attributes of chemistry. One of the retorts rests upon a mat of plaited straw. The cultivator, represented by an energetic and robust peasant wearing wooden shoes, is treading upon a branch of bramble bush, and holds in his right hand the mattock with which he la-

* The Marquis de Pastoret.
† M. Royer-Collart.
‡ The Count Daru.

* M. Magendie.

boriously tills the infertile soil. He has, moreover, suspended his work in order the better to listen to the enlightened advice of Science, whose demonstration he attentively follows. His eyes, fixed upon those of the young woman, eloquently betray his astonishment and the working of his mind. He feels that the future is in the new horizon that she gives him a glimpse of. These two figures are admirable in expression and truth. They are of bronze and about ten feet in height. The total height of the monument is about sixteen feet.

The body of the monument is of red marble from the Pyrenees. Upon the granite base, occupied by the two figures just described, stands a truncated column crowned by a bronze bust of Boussingault. Upon a shield, likewise of bronze, whence emerges a branch of laurel, is engraved the commemorative inscription: "Jean Baptiste Boussingault, 1802–1887." The different stones of which the monument is composed were dressed in the country of their origin. The putting of them in place necessitated considerable labor, as the monument stands right over a sewer that passes through this part of the courtyard of the Conservatoire. Mr. Jules Dalou, the sculptor to whom we are indebted for so many masterly works, was born at Paris, December 31, 1838. A son of artisans, he pursued his first artistic studies at the School of Design of Ecole de-Medecine Street, and then became a pupil of Abel de Pujol, Duret and Carpeaux, and entered the School of Fine Arts in 1853. In 1861, he exhibited a Roman lady playing at huckle-bones. The events of 1871 having caused him to retire to London, he soon made himself known by a succession of terra cottas representing female peasants clad in the large mantle worn by the women of Boulogne, and was chosen as professor at the Kensington Museum. His renown extended to France, where, after his return, he sculptured for the Chamber of Deputies the magnificent marble alto-relievo representing the session of June 23, 1789, at the Etats-Generaux. This work, in company with another representing the Republic, which decorates the City Hall, figured at the Salon of 1883. They gained for their designer the great medal of honor and the cross of chevalier. The eminent artist has since then exhibited a bust of Dr. Charcot, the Triumph of Silenus, the Tomb of Blanqui, etc. Finally, Mr. Dalou has obtained from the city an order for an immense allegorical group, the Triumph of the Republic, which is to be erected upon Place de la Nation, where the plaster model was inaugurated September 21, 1889. It was on the occasion of this that the sculptor received the rosette of officer.—Magasin Pittoresque.

GILLI'S CONGRESS OF DOGS.

WE publish herewith an engraving (for which we are indebted to our worthy contemporary, the Illustrirte Zeitung) taken from a painting by Alberto Gilli, entitled "A Congress of Dogs for Freeing themselves from their Masters." In this picture the artist has displayed his skill as an animal painter, for he has brought together dogs of all kinds, from the largest to the smallest, depicting them in most natural and characteristic attitudes, and, in fact, he has not confined himself entirely to the painting of dogs in this picture, but has introduced a number of monkeys, another species of animal that might be supposed to entertain a grudge against his master, man.

The monkeys in the group at the left of the picture are trying to urge their companion in training, a poodle, forward to represent them in the congress. On the opposite side of the picture stands a large St. Bernard which has boldly taken the floor and is setting forth his grievance. Most of the other dogs listen with apparent indifference, which may, perhaps, be accounted for by the presence of the master's whip and hat, although it is generally supposed that dogs are too faithful to desire to free themselves from even the most cruel of masters.

TRAMPS AS HUMAN BEINGS.

By MORRISON I. SWIFT.

AN investigator has estimated that there are 46,000 male tramps in the United States, costing the country from $8,000,000 to $10,000,000 annually. Eleven-twelfths of them are under fifty years old, five-sixths are able-bodied, and three-fifths have some occupation requiring skill.

No one regards the tramp with favor, and few think that there is any ground for his existence. The measures taken against him are, therefore, usually harsh and often savage. There is a favorite theory among those who have not tried tramping that tramp life is attractive, that tramps are inveterately opposed to work, and that the charm ought to be broken by a countervailing administration of stringent penalties and pain.

This method has been given a fair test in California during the past winter, and by its side a humane system has been under experiment. California is the winter rendezvous of Western tramps, of whom many move southward to avoid the Northern exposure. Sacramento fell into their hands for a while, just as the Legislature was about to convene, and "the people of the State capital were wildly excited over a regular epidemic of crime." The terror and danger increased, until a vigilance committee after the early pattern was formed, and the tramps were driven to jail "like sheep." "The committee found them in camp on the levee and in the lumber yards and vacant buildings. Their photographs were taken, and they were told to leave the city and never enter it again, or to take the consequences." But, as a San Francisco newspaper remarked, that rough-and-ready method offers no solution. One town or county drives the tramps on to the next; but this fails, for, as the tramp himself asks, "What are we to do when we get there? We are not wanted there any more than here." An arrest is equally futile and more expensive.

The method of discouragement applied to them was the time-honored ball and chain. The Herald of Los Angeles, where it was faithfully employed, gives the following description of its effects: "Every afternoon, at about four o'clock, the clashing of chains on Second Street, in front of the police station, attracts the passing pedestrian, and, turning, the members of the chain gang—poorly fed, ragged, and dirty—appear

THE CONGRESS OF DOGS.—FROM THE PAINTING BY ALBERTO GILLI.

to the full view of the tourist. Little children stand in droves and watch the poor fellows as they lift the balls and chains and stagger, half exhausted, into their squalid cells to spend the night. The people of this community are becoming tired of this relic of barbarism, and a movement is on foot to have some legislation passed to change the law by which these men are so shamefully degraded and ill-treated. The average member of the chain gang is usually some unfortunate fellow who has committed no crime save that of being poor. He is a vagrant, homeless and ragged, and he is gathered in by the police and sentenced. In the chain gang he is shackled and placed on an equality with a felon, and guarded as carefully as though he had been convicted of murder and sentenced to be hanged. For over a year the chain gang has been employed in cutting down the First Street hill. They are taken to work at seven o'clock in the morning, in several dirt wagons belonging to the street department, and a scant lunch packed in a box is taken along to stay their hunger until their return at night, when the regulation dinner of a square inch of boiled beef, a piece of bread, and bean water is supplied."

It was claimed by the police that a man need not work in the chain gang unless he chose to: but not to choose was to be put on short rations—a felicitous argument when the menu of the regulation dinner is contemplated.

The public could not settle down to perfect comfort while this was going on. The president of the City Council said: "I have always been opposed to the chain gang, for many reasons, the principal one being that it is too expensive to the city. . . . As matters now stand, the men are demoralized, and parading them in full view of the public, shackled, I think hurts the city." A clergyman condemned the system, saying: "It produces in the heart a repulsive feeling against government and laws, and creates a thirst for revenge which frequently develops into reckless and lawless conduct. . . . It is not reformatory. It does not teach a trade; it is a barefaced injustice, which creates a hatred for industry, and trains there men to shirk as far as possible the performance of labor."

One of the chain-gangers had been a rancher, and came to town with a few dollars to find something to do. He failed, and had been obliged to take lodgings in a box car. The police found him, and introduced him to the chain gang. One of his companions with the chain and ball had revealed the secrets and ease of housebreaking. He thought, when he got away from the "slop" and shackles and public exhibition and nightly vermin of the prison, he should not take the trouble to be honest any more.

Pomona, Santa Barbara, and Ventura were governed by humanitarian ideas, and obtained very different results. In Ventura they issued meal tickets, and required for each two hours' work. They also gave a lodging ticket for a third-class boarding house upon the same terms, but most of the men preferred to forego this luxury, and slept in the gas house. Nearly seven hundred of these tickets were distributed during the winter, and at least ten per cent. more in actual value than was expended was received back in labor. None of those working for the town were arrested for any offense. It was remarked by every one who saw them work that they did as well as those receiving regular wages. The principal promoter of the plan says that the municipality is, in fact, in debt to these men, because it took more work of them than it paid for.

The nature of the service was cleaning gutters, streets, and crossings, and some of the men remained a number of weeks. An old soldier was arrested for sleeping in a box car, and pleaded guilty of vagrancy. The justice did not have the heart to send him to jail, and he now is at work in a good place. After the ticket plan was adopted, there were no more calls for meals at the back door.

At first many people were in favor of making the labor as hard and disagreeable as possible, and were inclined to the chain gang and rock pile. "If we had had to depend on the humane for getting this thing into operation, it could not have been done," said one of the citizens. "We had to rely on the economical, that it would pay; and we proved it. The amount of work done was so obvious that it satisfied all the citizens. The quality of the work also impressed every one. Now the town would not think of adopting any other plan. The men were mostly industrious persons who simply could not find work to do."

The results at Santa Barbara were equally gratifying. In eight weeks 820 meal tickets and 270 lodging tickets were redeemed. A local writer said at the close of the winter: "There is no question but that the large majority of the men applying at the Labor Relief Yard are honest and industrious, and that their misfortunes are due to the dull times and the cessation or crippled condition of many industries. They are, as a rule, well-behaved, respectful, grateful, and glad of the opportunity to prove that they are not paupers. Some of them give evidence of education and breeding above the average. . . . The wages allowed the men in meal and lodging tickets are very small."

The law of humanity has not altogether asserted itself while opulent communities hire men in distress to work for such wages; but compared with imprisonment and prison support at the public cost, with the enforced rock pile, or with driving them out of town, how civilized!—The Outlook.

THE RUNNER'S REACTION TIME.

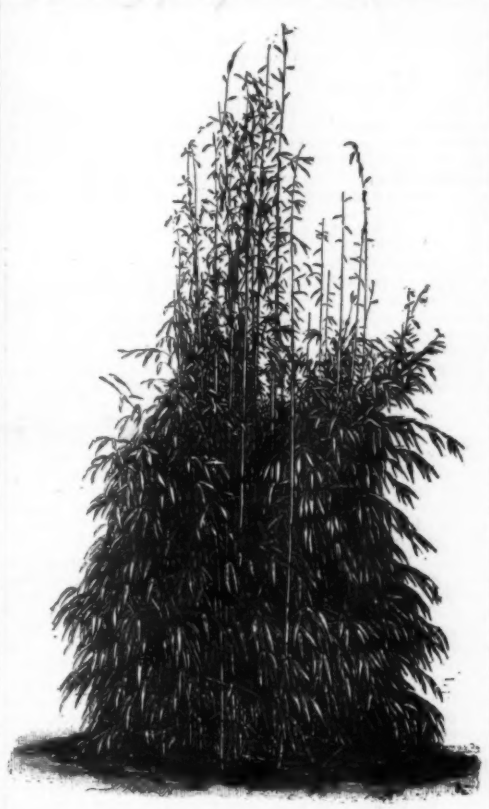
IN running sprint races it is very important to save even the fifth of a second. It has been proved by experiment that the time which elapses between the firing of the starter's pistol and the actual starting of the runner is long enough to influence the winning of a race. This is the runner's reaction time. An arrangement for measuring a runner's reaction time down to the thousandth of a second has been contrived in the Yale laboratory. The starter's pistol is arranged so that an electric contact is broken when the pistol goes off. A thread is attached to the right foot of the runner. This thread breaks an electric contact the moment the runner starts. Each of these electric contacts makes a spark on a smoked cylinder in such a way that the time which has elapsed between the first contact and the second can be measured.—Prof. E. W. Scripture.

HARDY BAMBOOS.

MR. FREEMAN MITFORD'S paper at the Royal Horticultural Society proved one of the best and most interesting lectures that have been read before the society. He had a grand subject and a novel one, and he handled it with the ease and knowledge begotten of enthusiasm and experience. It was by no means a compilation or a paper "made to order" or to fit an occasion. It is a matter for regret that it was not illustrated, either by specimens or by drawings. The society, as too frequently happens in such cases, missed an opportunity. Nevertheless, when Mr. Freeman Mitford's paper comes to be read in full in the journal of the society, there is no doubt it will give a great impetus to the culture of these graceful and singular plants, and the Bamboo Garden at Kew already furnishes an excellent object lesson open to the community at large.

We are apt to associate bamboos with something tropical, and dimensions too gigantic for an ordinary English garden. Mr. Mitford's paper will do much to correct this imperfect judgment. Big bamboos there are, and many of them far too gigantic and much too tender ever to find a place in British gardens, but Mr. Mitford gave a list of between forty and fifty species and varieties, all of which are of suitable size, some dwarf, and adapted for carpeting the ground beneath trees, and all more or less hardy. Indeed, after a winter which has in many parts of our islands destroyed even the common gorse, Mr. Mitford is able to say that not one of the species entirely failed. Nothing worse than a severe check has occurred, a check resulting in the formation of a sheaf of small canes, but richly provided with luxuriant foliage.

Mr. Mitford gave some excellent advice as to the necessity for not planting out the bamboos till they have recovered from the effects of their removal from their native countries or gardens where they have been



THE BAMBOO—ARUNDINARIA SIMONI.

grown. When received, the roots should be soaked in water for twelve hours, and then potted. They should then be placed in a cool house, and but little water given at first. In February the buds begin to swell, in March the leaves appear. Water should then be afforded freely. In May the pot plants may be hardened off, and at the end of the month they may be planted out in their permanent quarters, which should be duly sheltered from their deadly enemy—wind. In handling the plants the greatest care should be taken not to injure the roots, nor the points of the shoots, which are very brittle. They should not be trodden in, but the roots well watered in so as to enable them to get firm hold of the soil without risk of breakage. The soil should previously have been well double dug. By preference it should be a rich loam, and the plants mulched with cow manure. Wire netting may be provided to ward off the attacks of rabbits or pheasants. A little fern or bracken thrown over the stools in winter might be advisable. We need not follow Mr. Mitford in his enumeration of the species, but refer the reader to Mr. Bean's classification of hardy bamboos, given in our volume for 1894 (March), where the species cultivated at Kew and elsewhere are enumerated and described, with illustrative cuts, one of which we now reproduce as opportune to the occasion. Arundinaria nitida, one of the loveliest and hardiest, to quote Mr. Mitford, was formerly called A. khasyana, under the erroneous impression that it was a native of the Khasya Mountains, a hot, steamy region not likely to afford many plants hardy enough to withstand our climate. The species, it appears, is really a native of the Chinese province of Szchuen, a very different climatal region.

This instance, among many more, shows the great advantage that accrues from the association of botanical research and practical cultivation. The culture of those plants, as in the case of orchids, will lead to an immense advance in our knowledge of the plants, and to the gradual establishment of a correct nomenclature, and at the same time the information gleaned as to the native countries of the plants will afford most useful hints to the cultivator.

Incidentally we may mention a curious corelation alluded to, with becoming caution, by Mr. Mitford, and that is the circumstance that all, or almost all, the species known to be hardy have the smaller veins in the leaves arranged in small but conspicuous squares, the venation being, as it is called, tessellate.—The Gardeners' Chronicle.

THE AMERICAN CROW.*

"CORVUS americanus is found throughout the United States, with the exception of Southern Florida, where it is replaced by the sub-species floridanus; and the Central Plains and Southern Rocky Mountain regions, where the American raven (Corvus corax) abounds."

More or less abundant wherever found as a resident or as a migrant, with but one common name, it is perhaps better known to a larger number of people than any other species indigenous to North America.

Held up as emblematic of the fallen, defeated or unfortunate, the embodiment of cunning and cruelty, and published throughout the land as the personification of a knave and thief; is it any wonder that the ornithologist hesitates to defend the bird whose character is painted as black as its plumage? Like the blue jay, whom ignorance and superstition has accused of "carrying sticks to the devil," he is looked upon as the representation of evil, a sort of visible demon; and if he is not just going into mischief, he is popularly supposed to be just returning from it. Persecuted on every hand for many decades, in the East, it is a wonder that the species has not become exterminated. It has certainly decreased in Southern Pennsylvania, though almost imperceptibly, during the last fifteen years. Harmless, and even beneficial, two-thirds of the year, prejudice against it begins to wane.

It is not my aim to justify the destruction wrought by these birds upon the cultivated fruit, grain and vegetables, or the eggs and young of wild and domestic birds, for I know it to be considerable at certain seasons of the year; but I fully believe the benefits derived from their destruction of injurious insects, rodents, etc., and their work as scavengers largely offsets the damage done by them, if it does not indeed overbalance it. This applies to such districts as do not contain an overabundance of the birds.

To the bird's habitual watchfulness and acute senses, the situation of its nest, and to its breeding in the busiest time of the year, can be attributed its abundance to-day. Driven from the field by the hundred and one devices of the husbandman, shot, trapped and poisoned, they will continue to play the part Nature intended they should, and can only become extinct with the extermination of that which gives life to the country—the timber.

We are indebted to the pioneer ornithologists and to some of the present day popular writers (the latter making no display of scientific attainments) for almost all we know of the habits of this and many other common species. A well prepared bibliography is beyond the scope of this present article, and the following original notes on the general habits, flights, food, etc., contributed from widely scattered localities, will unquestionably be acceptable to those interested from a scientific or economic standpoint.

Dr. William Bringhurst, Philadelphia, Pa.—"The American crow remains with us throughout the winter season, retiring on the accession of severe weather to thickly wooded, hilly or mountainous regions. I live in a populous part of the city. At sunset crows may be seen winging their way to their roosting places in New Jersey, returning in the morning and retiring to long distances inland, though some may remain nearer to us. The pine woods of New Jersey afford them a safe retreat. Reedy Island, at the head of Delaware Bay, being solitary and at a distance from the haunts of man, used to be a famous resort for them, and likely is yet. They are astute birds, keeping well out of the way of man, seeming to know a gun from a stick. A pair built a nest in Logan Square and probably raised their young. As birds, animals, etc., are safe from molestation in these public parks, and can rear their young free from danger of attack by man, they soon acquire a degree of confidence."

John A. Bryant, Kansas City, Mo.—"To the public, the best known bird of all our species is the crow. This species is noted for its thievishness, and its high degree of cunning seems to go beyond mere instinct. It feeds principally on carrion, fish and insects, and the young and eggs of both birds and reptiles. Last spring I was a witness to this bird's great voraciousness. I was driving along a country road when I noticed a crow fly down into a farm yard, close to a hen with a number of chickens about two weeks old; it singled out a straggler, and deliberately pecked it two or three times, entirely disabling it. The chick's cry of distress brought the angry parent to the rescue. The crow was driven away a few paces; but a moment later, when the hen's attention was drawn away from the wounded chick, the crow seized his struggling victim, and flying a short distance, devoured it.

"As another case of this species' greediness, as well as its acute sense of danger, I will relate the following experiment and its result. One day last May, while fishing, I noticed a crow in the top of a dead tree, fifty yards or more away. It was constantly cawing and apparently watching me. Remembering the old darkey's adage, 'A crow knows a gun,' I thought it a good time to test the saying, so picking up my wooden fishing rod case, I walked toward the tree where the bird was perched some sixty feet from the ground. Having reached the tree I walked around the trunk and back to the creek, where I had left my gun, without the bird taking wing. On reaching the creek, I substituted the gun for the rod case, and again started for the tree. I had scarcely taken a dozen steps ere the crow decamped to another tree, nor could I approach within gun shot. I then placed my gun on the ground and attempted to get closer, but I found it as wary as before; the sight of the gun had destroyed all former confidence. On my return to the creek, my companion, who was further up the stream, called to

* Extracts from Bulletin No. 5 of the Wilson Ornithological Chapter of the Agassiz Association.

me to bring my gun. I immediately complied with his request, leaving the fish I had caught submerged in the water on a string. I was absent probably an hour. On approaching, I observed a crow sitting on a tree above where I had left the string of fish. Suspecting some mischief from its excited actions, I ran forward quickly to see what was up. The crow cawed rapidly three or four times and flew swiftly away. Simultaneously from the water's edge arose two more crows, acting on the signal given by the sentinel, in the tree. As they were eating the fish below the creek bank, they could not possibly have seen or heard my approach. I found nothing remaining exceepting ten eyeless heads strung on the cord, the crows having pulled the string from the water and eaten the fish on the ground.

"The great crow roosts of the Middle States, famous in pioneer days, seem to have diminished both in number of roosts and individual birds composing them. Southwest of this city there is quite a large roost, some members of which (400 or more by actual count) pass daily over the city to the Missouri River banks and sand bars, where they glean the refuse and debris washed ashore from the city. They congregate in November and disperse upon the breaking up of the winter frosts. As the season advances, a half dozen or less may be seen in some pasture or marshy place, where the grass is short, feeding on all kinds of insects and their larvæ, crustacea, and in fact all animal life too weak to resist or avoid their rapacity. For several seasons past a flock has frequented a marshy pasture, close to the public road near to the river. Among them could plainly be seen a pure white specimen. So often was it seen, that it became a matter of publication in our daily papers. Many attempts were made to secure this 'white crow,' but none were successful, as the wary cunning of the 'black crow' was predominant."

Lynds Jones, Oberlin, Ohio.—"In Ohio the crow is the terror of the corn field, and has been hunted until there is no getting near him. It is not strange if his nesting habits should conform to his general habit of watchfulness. Nests are often one hundred feet up in some such tree as shellbark hickory. I have never found a nest that could be reached without irons. In Iowa, the crow is not an enemy to agriculture, and so is not hunted to any considerable extent, but he is nevertheless wary and not easily taken. Flocks are usually composed of less than ten individuals, but I have seen hundreds of crows gathered together seemingly for some special purpose. There is always a prodigious cawing and much changing of position among the individuals at such a time; but when the flock rises, it disperses in all directions and apparently never comes together again, unless at some other rendezvous. It may be simply a coincidence, but the flocks that have come my way have appeared about noon on an early spring day. For so large a bird, its nest is remarkably near the ground. I have found many not over ten feet up in a thorn bush or scrubby oak."

Arthur H. Norton, Westbrook, Me.—"My observation on the nesting habits of the crow have been made from Rockland to Portland, Maine, in several localities, but nowhere more than ten miles from the coast. Near Rockland, especially on the small islands of West Penobscot Bay, and also the islands of a portion of Casco Bay; the most constant features of the landscape are the dwarfed spruce woods; but as we retire from the tide mark, on the mainland, we find a diversity of pine, oak, beech, etc., affording the bird a choice of nesting places. The nests that have come under my observation have invariably been placed in species of evergreen trees. The crows have a habit which seems to be constant, when their nest is nearly completed, of calling in the low, imperfect voice of their young, as we hear them in July. By this means, I have located most of the nests that I have examined." [Another observer from the same State makes note of this. Can it be a peculiarity of the Maine bird alone?—F. L. B.] "While common throughout the belt, it does not seem to breed abundantly in any portion of it. Each woodlet or wooded island may be the breeding station of from one to five pairs. Mentanic Island, in Penobscot Bay, annually supports about five pairs. This number may be stimulated by the desire to pilfer the night herons (Nycticorax nycticorax nævius), which also breed here in large numbers. On Crow Island, in the same vicinity, the densely foliaged white spruce (Picea alba) is the chief form of vegetation, and in these trees the birds formerly nested, building very low (about ten feet from the ground). The island is uninhabited and seldom visited by man. In 1885, the raven (Corvus corax principalis) took possession, and no crows nested there that season. There is constant warfare between the two species."

H. R. Buck, Wethersfield, Conn.—"Crows are very common with us at all seasons and especially so in winter. Then they collect in large flocks, probably recruiting from much further north, and keep together pretty well until the breeding season. As a rule they spend the nights in the meadows of the Connecticut River, roosting in large numbers in the black oak trees, which are abundant in many places. At such times they are perhaps less watchful than in the day time, but nevertheless they always have guards posted, day and night. They can seldom be approached without the guards giving the alarm. Some twenty years ago my father shot sixteen by firing the contents of a double-barreled gun into a tree where they roosted. About dawn they begin to stir, and from sunrise until noon there is a steady stream of them flying to the neighboring hills, where they pass the day. Here they feed on berries, seeds, and almost anything they can pick up. They undoubtedly do good by killing larvæ and grubs, which they find under bark and leaves. Warm brooks are among their favorite feeding grounds, and they sometimes come quite close to farm yards in search of such scraps as may be thrown out. When the spring thaws come, they may be seen almost constantly feeding on the edges of the melting ice, sometimes in company with the herring gull (Larus argentatus smithsonianus), which often comes up the river. Here they find acorns, berries, and the garbage from towns further up the river. They also collect in large numbers about the city dumps, showing a great fondness for carrion, and all refuse found in such a place.

"As the season advances, they abandon their routine habits, break up into smaller parties, and finally into pairs, when they set about the more serious business of nesting. In this locality they seem to like the sunshine, and avoid the deeper woods. When the eggs hatch, 'then the trouble begins' for the farmers, as the corn comes up about that time and the young birds must eat. I do not think the crows dig up the kernel before it sprouts, but from the time the blade first shows above the ground until it is three inches high, they seem to consider it their lawful property. They pull up the sprouts for the kernels at the end. The crow does great damage in this way, especially in isolated fields, where the whole crop has sometimes to be replanted. There are two methods in use here for preventing this loss. The first and oldest way is to stretch white cotton strings around and across the field about six feet above the ground. The crow proverbially is a cunning bird, and when he sees the strings, he expects a trap and seldom goes into the fields. This way has been largely given up on account of its inconvenience and cost. The way now followed is that of coating the corn with tar. This gives a bitter taste to the kernel, so the crows let it alone after pulling up one or two spears. The usual way of preparing the corn is to pour hot water over it and let it soak awhile; then for every bushel of corn, put in perhaps a half pint of 'North Carolina tar,' as it is labeled. This is better than the coal tar, because it does not have to be melted. The water is then poured off and plaster, ashes, or sand is mixed to keep the kernels from sticking together. This hinders the growth probably a day or two, but it is a perfect protection from the crows. Last spring our tarred corn gave out and we finished the last rows of one piece with clean corn. After it had come up, we found that the crows had pulled every spear of this corn, while the tarred corn at its side was hardly touched. The damage done to corn is not confined to the first few days. When it is in the milky state, they tear the husks and eat off the kernels at the tips of the ears. The harm done in this way is not great; the purple grackles, red-winged blackbirds and English sparrows doing vastly more damage than the crows. On the other hand, the crows undoubtedly eat injurious insects, mice, moles, snakes, etc. April 15, 1893, I saw a crow kill a grass snake. It would have eaten the snake had not some boys frightened it away. During spring plowing the crows follow in the furrow to get the grubs that are turned up. Crows are much less abundant here to-day than ten years ago, and I am told that thirty years ago there were twenty where now there is one."

NIDIFICATION.

SITUATION.—The crow usually chooses a tree situated as deep in the woods as possible, or in some quiet little grove of tall trees, where it can nest free from molestation and yet be near to its chosen feeding ground. The number and variety of eligible situations, the individuality of the bird, the degree of hostility prevailing in its neighborhood and the consequent measure of activity displayed by its enemies, having a large share in influencing the selection of a nesting site. Now and then a pair bubbling over with boldness or over-confidence in man will build in an isolated tree, usually but not invariably an evergreen, in the middle of a field or in an apple orchard. Mr. Frederick M. Dille collected a set of eggs from a tall cottonwood, in the midst of a dense grove, on Clear Creek, directly on the outskirts of the city of Denver. He says: "I was greatly surprised at finding a pair of crows breeding in such close proximity to a large city; but the birds were very quiet and retiring, as if they realized the delicacy of their situation." Mr. W. N. Clute, Binghamton, N. Y., cites two instances of this species nesting within the city limits. Dr. William Bringhurst, Philadelphia, Pa., takes note of a pair building in Logan Square, on one side of which stands the Academy of Natural Science, on another a grand cathedral, etc., every front being built around, and the square much frequented. At a later date, the same gentleman informs me that he has heard of a nest established among the trees of Independence Square right in the heart of the oldest portion of the city. It would surprise me little to learn that this was correct and that this saucy bird had raised its young within touch of the "Cradle of Liberty."

Mr. A. H. Norton, Westbrook, Maine, writes: "The first nests that I have found each season have been built in trees at the border of an opening or grove, where the snow has disappeared, the point of the compass not, as might seem probable, having influence. The southern exposure receives the sun's action, but the wind and water frequently are as rapid in melting the snow from northern or northwestern exposures. The bird seems to like the sunshine (or society) and avoids the deeper woods." Mr. Henry W. Carriger, Sonoma, Cal., has found the nesting sites extremely variable, finding them in deep woods, groves and along sloughs. He writes: "Previous to 1891, about ten pairs nested in a grove of young white oaks, but in 1892 not a nest was to be found there. The birds had gone, for some unknown cause, to a large grain field, about four hundred yards distant, where they built their nests in large white oaks." Mr. Edmund Heller, Riverside, Cal., states that the crows in that vicinity nest only on the bottom lands, never in the canons nor on the mesa. Large tracts in that section are without their quota of birds. Mr. Samuel L. Bacon, Erie, Pa., writes: "My observations lead me to believe that, if unmolested, a pair of crows will nest in the same vicinity for many years, if not for a lifetime. To corroborate this belief, I will say that a pair of crows (presumably the same pair) have nested for the past four years in one piece of woods, and these four nests are within two hundred feet of each other. In these woods, which cover about three acres, there are the remains of at least ten other nests, and I feel sure they were built by the same pair." Mr. C. W. Crandall has usually found them breeding in low woods, with parts swampy or containing a small pond, on Long Island, N. Y. He also gives some notable situations. One nest fifty feet from a habitation, in a gigantic elm, at the roadside, another one hundred feet from a group of houses, another not more than thirty feet from a railroad in constant use; another, one hundred feet from a nest of red-shouldered hawk. Mr. Lionel F. Bowers, Columbia, Pa., and Mr. Arthur H. Norton, Westbrook, Me., have found their nests situated in the midst of black-crowned night heron colonies. I have found them close to the nests of the Cooper's and broad-winged hawks, which they will rob if left uncovered for any length of time, and also in one instance within a few yards of a gray squirrel's nest.

POSITION.—The nest is usually placed in the upright fork or crotch of a tree, not seldom on a horizontal branch, at no great distance from the main stem. Mr. C. W. Crandall discovered a nest on Long Island, N. Y., in a most peculiar and unique position. In his own words: "Looking from the brow of a hill some thirty feet high, I discovered a nest situated in the fork of a chestnut tree, which was at the base of the hill, the nest being placed forty-five feet up. The parent bird was sitting, and strange to say, was entirely visible from where I stood. Thinking this was very peculiar, I resolved to investigate. Upon climbing to the nest, I found that by some means, probably a heavy wind, it had become dislodged and had turned almost completely on its side, the eggs just being held in by the rim of the nest. The bird had to sit with one side against the bottom of the nest, with the other side exposed."

HEIGHT.—The distance from the ground at which the nest is placed varies from four to over one hundred feet. Where the birds are unmolested, they build remarkably near the ground, for so large and naturally suspicious bird. Where they are persecuted and continually hunted, the instinct of self-preservation, with which they are most certainly highly endowed, prompts them to build in practically inaccessible trees in many cases. Such trees as shellbark hickory, sycamore, large crooked black oaks, trees overlooking precipices or deep water, are often very difficult to climb, and the crows often build their nests at a great height in those trees. Where the bird chooses an uninhabited island, an unfrequented swamp or the deep woods for breeding purposes, the nest is usually placed much nearer the ground than it would otherwise be. On the whole, mankind exercises more influence over this than is generally known. The average height throughout the country is about forty-five feet. Minnesota, North Dakota, Manitoba are but thinly settled, and the average height from the ground is found to be only twenty feet. The soil of the Eastern States is in a high state of cultivation, and the New England farmer looks with an unkindly eye at the depredations of this black-feathered bird. His search for food is interpreted as a raid which must be resisted by force of arms; hence the bird becomes shyer and builds as high up as it is possible to do. The data before me give an average of sixty feet above the ground.

[FROM SCIENCE.]

THE GEOGRAPHICAL DISTRIBUTION OF THE MOLLUSCA.

WE hear a great deal of late concerning the habits, range of variation and special characteristics of a great number of forms of life; but very little is written concerning the methods by which species peculiar to one locality may be transported to others many miles distant. This is a subject which bears more closely on the origin of species than any other, and one which will yield some of the best results, if studied carefully and faithfully, and if original observations are made in the field. It is my purpose in this communication to briefly consider some of these transporting agencies as illustrated by the Mollusca, from facts gathered by myself while collecting in the field and from reliable correspondence.

Distribution by the Aid of Birds.—Several years ago while on a collecting trip to Florida I took occasion to dissect several hundred migrant and resident birds and to carefully note the contents of their crops. In a large number of the crops I found the shells of mollusks which had been taken as food; these shells were mostly minute and of the genera Pupa, Amnicola, Pisidium and Vertigo. These shells, being indigestible and not affected by the gastric juices of the stomach, would naturally pass off with the fæces. In this manner the shells of many species of mollusks which were once supposed to inhabit restricted localities have been found at a great distance from their recorded habitats. Especially would this be true during the migratory season, when a bird would swallow a species in one State and drop the shell with the fæces in another. The shells, of course, would in most cases be dead when dropped, the animal portion being used as food; but there are exceptions to this, for I have several authentic accounts of living mollusks being found in the stomachs of birds. As an example of the wide distribution of these small mollusks, I cite Pupa armifera, Say, which is found from Dakota and Kansas to the Eastern States and Mexico.

The Catbird (Galeoscoptes carolinensis) I found to feed only (so far as the mollusca were concerned) on the minute land snails Pupa and Vertigo. It was frequently observed on the palmetto trees searching for these minute animals. The hawks and kites of Florida, especially the Everglade kite, seemed to consider the animal of Ampullaria depressa, Say, a great delicacy, for in almost every crop dissected I found the remains of this mollusk. Heaps of the dead shells of this animal were always found beneath their roosting places. Frequently a hawk or kite will capture this fresh water snail and carry it several miles to its roosting place; but many times another bird will overtake the one carrying the booty and a dispute of ownership will follow, which nearly always results in the loss of the prey, which drops unharmed, perchance, into a pond which this species has not before inhabited, and there, if laden with eggs, as is frequently the case, establishes a new colony of Ampullaria. By this means, as well as others, this species has been distributed over a great portion of Florida. It is my belief that many a colony of mollusks, as well as other animals, has been formed in this manner.

Ducks, geese, swans and many other kinds of wild fowl are very fond of snails, and I have never failed to find the remains of them in their crops. By means of these birds the shells of many mollusks have been transported for many miles and have offered, doubtless, material over which some conchologist has worried and finally described them as a new species! I know of several instances where the eggs of a mollusk were found attached to the foot of a mallard and

several birds have come under my notice which, when shot, had young Anodons and Sphæriums adhering to their toes. Many other instances might be cited of this character, but enough has been said to show that birds exert a wide influence in the distribution of the mollusca.

Distribution by the Aid of Fishes.—Various species of fish feed upon snails as a regular diet. After feeding in one spot they repair in schools to some particular spot, often many miles distant from the feeding ground, where they digest the animal and eject the shell, either through the mouth or with the fæces. In this manner littoral mollusks are carried to the abyssal regions, and, I believe, have been described as deep sea forms. The greater portion of the foregoing accounts relate only to the dead shells which have been ejected from the stomach of some vertebrate animal and the change cannot be said to be a correct variation in habitat, save in the few cases cited where the living animal was transported; it is simply the dispersal of a skeleton from one point to another.

Dispersal of the Living Animal by Means of Insects.—It would hardly be supposed that insects could in any way be the means of distributing mollusks, and yet I have numerous records of such distribution. Some time ago a water beetle was captured, which had a Sphærium attached to one of its legs; another species was captured with an Ancylus attached to its wing case. I have records of other instances where the larger water beetles had specimens of Physa, Planorbis, and even Limnea attached to different portions of them. In this manner living mollusks have been transported from one pond to another, and so many of the freshwater species have been distributed by the humble means of a water beetle.

Distribution by Means of Storms, Ocean Currents, etc.—We may now consider a change of habitat which affects the living animal more closely than in the cases previously cited. Many portions of Florida bordering the rivers and creeks are continually falling away and being carried into the Gulf, and so to Cuba, Yucatan and other parts of the West Indies and Mexico. These transported masses consist of tree trunks, entwined vines, branches and roots of trees covered with earth and vegetation. Many times during storms whole tracts of land are washed away and portions of them of considerable size are carried many miles by the currents. Upon all of these natural rafts mollusks are found which are transported to habitats a great many miles from those in which they first appeared. In this manner Helices, Bulimi, Pupæ, Limæa, Physa, Planorbis, and a host of species too numerous to mention, are carried from the Southern States to Cuba, Mexico and Yucatan. No doubt many of the species of land and fresh water shells found in Cuba which are also found in the Southern States, especially Florida, were carried there in this manner, or were carried from Cuba to the States.

In the Western States fresh water and land shells are continually being carried from one point to another. In the early spring, when freshets and floods occur, the young fry, as well as the adult animals, are carried from the headwaters of the Mississippi River to various places along its banks upon driftwood, tree trunks and an innumerable number of natural rafts of this character. In this manner the species of Unio have reached a comparatively wide distribution. So also in our Great Lakes the fry of mollusks are carried from Huron to Ontario. Mountain streams, during freshets, are potent vehicles of transportation in the spring, and no doubt many mollusks living at high altitudes are carried by this means from the mountains to the valleys and plains below. As an example of this I cite the following case, furnished by a reliable correspondent: About two years ago a colony of Vitrina limpida was found in a Pennsylvania town just after a severe flood; the species had not been before observed, although the collector had searched the locality for several years preceding. These shells had undoubtedly been brought down the Alleghany River on rafts during the flood, and the little colony had been formed. From last accounts the little colony was doing well. This is but one example of many which prove that mollusks are distributed in this manner. I have one authentic case of a number of Anodons being carried away by a whirlwind and falling several miles distant during a severe rainstorm.

Distribution by Human Agencies.—Man has been a great factor in the distribution of all animal and vegetal life, and the mollusca are no exception to the rule. The great Erie Canal has been a powerful transporting agent. In it we find species of Physa, Limnæa and Planorbis, which were once supposed to inhabit only the Western lakes and rivers. Even European species, like the giant Limnæa stagnalis, have been brought over from Germany and France, and are now found from Illinois to New York; so also with several small Valvatas and Amnicolas. Land mollusks have also been brought from Europe, either adult or in the egg, and we now have several colonies of Helix nemoralis and H. hortensis in several parts of the United States. In the city of Mexico, in a little corner of the cypress grove at Chapultepec, is a large colony of Helix aspersa, which, up to the time of its discovery, in 1890, was not supposed to be found in Central America. It is now spreading over the valley of Anahuac, and will before long be a recognized part of the fauna of Mexico. This species was undoubtedly brought to Mexico with German goods, found a locality favorable to its existence, and has grown and multiplied. This same species is now found in Charleston, South Carolina; New Orleans, Louisiana; Portland, Maine; Nova Scotia; Santa Barbara, California; Hayti; Chile, etc. It is a curious fact that Helix hortensis was not accidentally introduced into the country, as were H. nemoralis and H. aspersa, but was first brought to Burlington, New Jersey, by Mr. W. G. Binney. This species does not thrive so well, nor does it spread so rapidly, as did the other species mentioned.

Our large garden slugs, Limax maximus and L. agrestis, were introduced into this country some fifty years ago, and are now found all over the northeastern part of the United States and parts of Canada. The transportation of hothouse plants has been the principal means of distributing these species, for they are found more abundantly in greenhouses than in any other locality. Geological changes also tend to disperse mollusks and also to change their mode of living. A single example will suffice to illustrate this point. In Africa there is a lake (Lake Tanganyika) in which live a number of mollusks almost identical in the form of the shell and animal with the marine group of shells known as Trochids; yet these mollusks live in fresh water and have the principal characteristics of fresh water species. Now this lake must at some time have been connected with the sea, and the change from salt to fresh water must have been very gradual in order not to have killed off all the animals. Numbers must have died during the change, and those that were the most enduring lived and multiplied. The result of the change is some of the most curious mollusks known to science. (Limnotrochus, Tiphobia, Neuthauma, Tanganyicia, etc.)

And thus I might go on and give hundreds of examples of the distribution of mollusks by natural and artificial methods; but I believe I have given enough to illustrate my point, which is that there is nothing so very wonderful in the finding of species hundreds of miles from their supposed natural habitat, and that the apparent "paradox" of their discovery can be accounted for by some one of the examples given above. More attention should be given to the careful recording of facts such as those I have given, which are to my mind far more valuable to science than the indiscriminate description of new species and genera, and a multitude of such facts would aid very materially in the solution of the origin of species, and the reasons for the gradual change from one type to another.

FRANK C. BAKER.

The Chicago Academy of Sciences.

THE THUMB AS AN INITIAL FACTOR OF CIVILIZATION.*

By W. R. WHITEHEAD, M.D. (Paris), Denver, Col.

Ex-President of the Colorado State Medical Society; ex-Professor of Anatomy in the Medical Department of the State University of Colorado, and also in that of the University of Denver, etc.

"Pollex . . . manus parva, majori adjutrix."

HAD primitive man possessed hands without thumbs, he would have been a very helpless creature, less capable of self-preservation than the thumbless spider-monkey, which has a prehensile tail useful to it in many ways. Had he possessed thumbs not better developed than those of the anthropoid apes, he could not have made and used weapons of attack and of defense, nor made improvements in the conditions of his life. Indeed, the most essential difference between the human hand and that of these animals is that the hand of man has a thumb which is moved independently of all the other fingers by means of the long flexor muscle of the pollex, and which enables him, with the aid of the other fingers, to spin, weave, mould, and fashion articles of necessity to the various purposes of his life. It is said that this muscle was called by the late Oliver Wendell Holmes the "muscle of civilization." I believe that Dr. Holmes rightly deserved the distinction of being the first who had the genius to so name it.

No attempt will be made in this article to speculate concerning the evolutionary changes of apish hands, or to offer any suggestions as to how primeval man acquired by elimination, through disuse of certain muscles or otherwise, a separate and distinct single flexor tendon to the flexor longus pollicis muscle. That such an anatomical arrangement does exist in the human hand, and not in the hand of apes, or in that of any other creature, is a well attested fact; and the result is, that man only can bend his thumb separately from and independently of the other fingers, which makes of it a perfectly opposable member that pre-eminently distinguishes man from all other animals, and made civilization possible. It is beyond our ken to tell how this came about, quite as much so as to explain how the eohippus became the horse of the present day, with its splint bones as vestiges of a former five-toed and five-fingered animal.

The study of the thumb in its relations to the life of man is an extremely interesting subject. There is quite enough of interest attached to it to command the anxious attention of the physician to any conservative measures which may prevent loss or impairment of the thumb as the result of its disease or injury; and the past and present relations of the thumb to the arts of civilization, and through them to the many material comforts and conveniences of life, are sufficiently important to make this a practical subject to all. Consequently a restricted and comparative study of the human hand with that of apes, as it exists at present, and presumably existed in primeval times, is not trenching upon the subject of evolutionary development, which required inconceivably long periods of time for its accomplishment, as shown by Haeckel and others, and to which the ordinary span of human life is but as a fleeting moment. I shall assume, therefore, as quite sufficient for my purpose, that primitive man was supplied with a long flexor muscle of the thumb having a single tendon only, and that he had suitable hands adapted to the numerous handicrafts and arts of a future civilized life. Truly this assumption is fully justified by a similar thought figuratively expressed in the following lines, attributed to Cicero, in which the human hands are typified as the serving maids of numerous arts:

"Natura dedit homini manus aptas, et multarum artium ministras."

The exquisitely shaped vase that takes form under the rapidly moving hand of the expert potter, with the aid of his wheel; the delicate outlines of a beautiful statue which seems to grow into existence, instinct with life, under the chisel of the sculptor, and the pleasing designs and harmonious blending of rich, warm colors which follow the deft use of the weaver's fingers in the making of an Oriental rug or of a Gobelin tapestry—these and a hundred other uses of the hands of man give force and realism to the above quotation, and show that primarily the perfectly opposable human thumb was indispensable to the growth of the intellectual faculties of man and to his civilization.

The flexor longus pollicis muscle of man is the great opposable muscle of the thumb, and might very properly be called the opponens proprius pollicis.

The opponens pollicis, more aptly called the flexor ossis metacarpi pollicis, is a weak little muscle of the outer part of the ball of the thumb which feebly flexes and partly abducts the metacarpal bone of the thumb. It is an error to speak of this muscle, which is accessory in its action to that of the adductor pollicis, as an "opponens" muscle. Such errors are misleading, but occur in anatomy as elsewhere; indeed, every practical physician knows that the rectum is misnamed, that it is not straight, and might be more properly called curvum.

The remarkable freedom of movement of the metacarpal bone of the thumb, due to the saddle-shaped surfaces of its arthrodial articulation with the trapezium, permits of great mobility of the entire thumb; this mobility is especially useful to the potter and to other artisans in the exercise of their crafts.

A most important structural peculiarity of the human thumb is that the whole of it is in a plane anterior to the rest of the hand, and faces across the extended palmar surfaces of the fingers and hand, so that when the phalangeal parts of the thumb are flexed, by the action of its long flexor, they are bent across the palm of the hand, and not in a direction parallel with the fingers, or nearly so, as in apes.

The short muscles which form the ball of the thumb are very similar in man to those of apes; but in the well developed, rounded ball of the thumb of artisans they exert a powerful action in drawing the metacarpal bone inward, especially the adductor pollicis and the short bicipital flexor of the pollex. These muscles enable the sleight of hand performer to hold and conceal small objects in the palm of his hand, and are exceedingly useful to the mechanic in the handling of tools and in certain manipulations of the artisan.

Two extensor muscles of the thumb, the primi internodii and secundi internodii pollicis, powerfully retract the thumb, and when so retracted the tendons of these muscles form on the back of the wrist a notable depression, at the bottom of which is the radial artery as it curves in its course to form the deep palmar arch. This depression, large enough to hold a pinch of snuff, is the well known tabatière anatomique of French anatomists.

The primi internodii pollicis is absent in apes, but the extensor ossis metacarpi pollicis is excessively developed in these animals, which permits of a more extended retraction of the thumb than in man, and which is especially useful to apes in their arboreal habits of climbing and of grasping objects.

Indeed the function of the hand of apes is limited to the grasping of objects and to such simple motions as quite unfit it for mechanical or artistic work. No apes, on account of their imperfect thumbs, could balance and throw a spear with accuracy, or discharge an arrow from a bow; none could twirl the distaff and twist a thread of flax with their thumbs and index fingers.

Even if the higher apes had possessed hands like those of man, it is extremely improbable that they would, on account of their structural dissimilarity to man in other respects, have been his rivals in the struggle for supremacy. Indeed, notwithstanding the generally man-like appearance of the higher apes, none of them are without some structural peculiarities which widely separate them from man, and which make it impossible to trace its descent to any particular kind of ape. As an illustration, the orang, which has the most human-like brain of all apes, possesses very short and imperfectly developed thumbs. It is mentioned by Mivart, as first pointed out by Gratiolet, that the spider monkeys, which are thumbless and have long prehensile tails, have in their brains the human-like annectent or "bridging convolutions." These folds of brain substance exist in the brain of the orang. The thumbs of the gorilla, of the chimpanzee, and of gibbons are relatively smaller than in man and rather human-like, but they are not better developed than those of the Rhesus monkeys (Macacus); and indeed baboons, the most brutal appearing and lowest of the Simiadæ, have better developed thumbs, and some other parts of their anatomy, as the penis and other organs, are more human-like than many apes above them. It is stated by Mivart that the thumbs of the indris and of typical lemurs, or half-apes, are more completely opposable and better developed than those of any apes. It appears that the organs of apes which most resemble the same organs of man are not all assembled in any one kind of ape, but seem to be confusedly assigned to very dissimilar apes, and even to half-apes, as if to oppose a barrier to those who shall attempt to trace a too near kinship between these animals and man.

In apes the muscular fibers of the long flexor muscle of the thumb and of the deep flexor of the fingers are more or less intimately blended, so as generally to make of these two muscles, which are separate and distinct from each other in man, a single muscle in apes which by its contraction bends the thumb and all of the fingers of the apish hand simultaneously. Hartmann claims that the long flexor muscle of the thumb is absent in the gorilla, chimpanzee, and orang, but may be traced in the white handed gibbon. This is not confirmed by Huxley; but Hartmann's statement, however, tends to establish more fully the fact that no independent and separately acting long flexor of the thumb exists in apes as in man. According to Hartmann, Langer and Bischoff describe, in addition to the short bicipital flexor of the thumb common to man and apes, a short independent flexor muscle representing the long flexor of the thumbs of apes; but Hartmann states that he has never ascertained the existence of such a muscle. In the orang the thumb is very short and almost rudimentary, as is generally conceded, and has simply a fibrous expansion and no tendon at all to it from the long flexor muscle of the thumb. The loss of this muscle as a thumb muscle, according to Huxley, sometimes occurs in the gorilla; usually, however, he observes, the long flexor muscle of the thumb in the higher apes, as in the chimpanzee and the gorilla, is blended at its origin with the deep common flexor of the fingers, perforans, and instead of furnishing a single tendon which goes to the thumb, supplies one to it and one also to the index finger. The result of this, as can be readily perceived, is to make the index finger and thumb of these apes approach each

* From the N. Y. Medical Record.

other independently of the other fingers; in fact, all apes which have this arrangement are able to seize small objects with the index finger and thumb, as they are known to do in the removal of thorns and burrs and of parasites from the bodies of each other. As mentioned by Darwin and others, this has been often observed, and also that some monkeys open mussel shells with their two thumbs; others crack nuts with stones and seize sticks and stones and hurl them clumsily at their enemies.

The great toe or hallux of many apes is more developed than their thumbs, which adds greatly to the grasping power of their feet. The spider monkey, which has no thumbs at all, has a very opposable hallux. This was well observed by me recently in examining a Chameck spider monkey at the Elitch Zoological Gardens of Denver.

The orang, which has such a defective thumb, has an exceptionally well developed and powerful hallux, like the spider monkey The hallux of the orang has a special muscle to flex it, known as the flexor longus hallucis, and which takes its origin from the external condyle of the femur.

The mutual relationship between the uses of the hands of man and the growth of his intellectual faculties becomes apparent in the study of the correspondence between inventions and the development of the human mind. This is especially noticeable in the study of the origin of civilization, and indeed is appreciably so in the study of the intellectual development of young children.

The natural adaptation of the hands of the child to the handling of its toys is one of the most instructive aids to the growth of the infant mind. Knowledge thus acquired is due to the natural ability of the child, on account of its perfect hands, to handle with facility and accuracy its dolls, wooden soldiers, building blocks, animals of a Noah's ark, and other playthings at its own sweet will. Indeed, it is the delight of the child to move them about, push them along, and if so disposed to break them to pieces, and aided by its imagination make them serve as symbols of other things. To the child's imagination these objects are, in play, endowed with life and activity, and are real soldiers or living and moving beasts, or represent real houses or castles. Such playful occupations enlarge and give definite shape to the child's ideas, and develop its powers of analysis and of combination. Hence such manual adjustments and combinations of objects, characteristic of the use of the human hand because of its peculiar structure, make it a potent factor in the growth of the intellect. Primarily, without this influence of the uses of the hand on the mind there would necessarily have been an arrest of mental development; hence it is not astonishing that Anaxagoras and some other eminent philosophers thought that man's superiority was attributable to his hand.

From the dawn of civilization to the present time, the growth of the human intellect has been in close and more or less dependent relationship with the different arts and handicrafts of man. The invention of machinery and of labor-saving appliances and the fuller development of the mind has made it apparently the dominant factor in human progress, as it now really is.

The extremely tardy growth at first of the intellectual faculties is shown by the history of early inventions. Mental development was primarily dependent on scant knowledge, irregularly, painfully, and patiently acquired, during enormous periods of time, evidenced by the paucity of inventions and by the immature art discoveries of remote ages. The development of the human mind beyond the intelligence of brutes would never have had a beginning if primitive man had not possessed perfect hands with perfect thumbs, adapted to the use of weapons of attack and of defense and of primitive implements of general service.

Some savage tribes of Australia and of Africa, as quoted by Sir John Lubbock in his "Origin of Civilization," etc., attached such great importance to the thumb that they cut off the right thumb of a dead foe, believing that the spirit of the deceased, thus unable to throw the spear or use other weapons efficiently, could do them little injury.

As an early result of mental growth, articulate speech was slowly and gradually evolved, and also gesture and sign language, which facilitated the interchange of the ideas of primeval men concerning matters of mutual necessity such as the fashioning of their weapons or of fire making; all of which required the associate working of the hands and brain. Indeed, the lighting of a fire in a primitive manner, as Peschel, E. B. Tylor, and others have so fully explained, was often not unattended with some difficulty, and exacted the laborious use of the hands and the practiced exercise of the fingers and thumbs to start a blaze. But no uncivilized races of men, according to Peschel, have ever been found unacquainted with the art of lighting a fire, and who were without an articulate language more or less regular and complex, which last, probably, led to the belief in the divine origin of articulate speech, and which is truly one of the greatest aids to the growth of the intellectual faculties. Spoken language, however, is not indispensable to the cultivation of the mind, as is evident from the sign language of deaf mutes, whose thumbs and fingers express in a most intelligible manner to each other the thoughts and activity of their minds, which are capable of a very considerable development.

Darwin remarks that man could not have attained to his present dominant position in the world without the use of his hands, and further pertinently quotes Sir Charles Bell as saying that the hand supplies all instruments, and by its correspondence with the intellect gives to man universal dominion.

Prominent writers on primitive man and kindred subjects, and most anatomists, notwithstanding they are probably acquainted with the anatomical difference between the thumbs of apes and of man, seem, however, to have overlooked or failed to appreciate this difference as originally the chief and initial cause of the mental development of man.

The intimate relationship between the uses of the human hand and the growth of the intellectual faculties, so different from that of the highest apes, enlarged to an almost illimitable extent the capability of man to effect improvements in the conditions of his life. In addition to his capacity for mental development, to his ability to acquire articulate speech, and to his possession of perfect hands, adapted to the uses of the craftsman, modeler, sculptor, and artist, man is distinguished from all other creatures by his erect posture, his firm and well balanced step, and by his graceful and commanding form. The harmonious adjustment of these human qualities to the conjoined uses of the hands and intellect, mutually reacting on each other, has gained for man his dominant position in the world.

It is upon an intelligent artisan class, necessarily restricted in its numbers and more skilled than ordinary mechanics, that the world depends to model and make the machinery and appliances now necessary for the manufacture of things formerly made only by hand. Thus it has been, and always will be, primarily, to the cunning of the human hand that nations are indebted for their superiority in the mechanic arts. Should, from any causes, this class become inefficient, or be driven out of a country, a retrograde movement in national prosperity must inevitably follow, as was the case in Spain, time of Philip II, and in France, time of Louis XIV.

Wise is the policy of that government which fosters the mechanical industries of its own people. Indeed, the greatest material progress and prosperity, in these times, is for that nation which can make and use the best machinery and the best cannon.

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THE USE OF THE BICYCLE.

IN the Journal des sciences médicales de Lille for August 3, M. H. Lavrand gives a résumé of a discussion in regard to the bicycle which took place at a recent meeting of the Société de médecine.

M. Lucas-Championnière presented the question from a hygienic point of view. The bicycle, he said, had been condemned as a means of exercise for women, and had been thoughtlessly compared to a sewing machine, to which it was not at all analogous. It had been said to cause deformity, but this accusation showed a want of reflection and a profound ignorance of anatomy and of physiology. In reality, all the muscles came into play in order to propel the machine and to keep one's equilibrium; consequently the vertebral muscles could not but increase in size and in power. The first action of the bicycle was to develop the muscles, not only those of the legs, as was commonly believed, but all the muscles of the body, and in this exercise M. Championnière thought we had the most perfect method for muscular development. Its action on the general health was also evident. The manifestations of nutrition were profoundly modified; an examination of the urine had shown this. The increase of the proportion of urea had indicated a greater waste. The influence on the heart was also very evident, and any excess in this exercise was prejudicial. One of the most valuable advantages of this form of exercise, however, was that it put the heart into a good condition of resistance. With regard to the benefit to the lungs, it might be said that the good results were almost immediate, if care was taken to avoid the chill which was always apt to follow any prolonged exercise.

M. Marcel Brand thought that this form of exercise was the best that could be employed in the treatment of the vicious habits of adolescence, and he cited several cases in which recovery had been obtained when all other treatment had failed. The majority of affections dependent on the diminution of nutrition were favorably improved by the motion of the treadle. With regard to neuropathies, he said, the most favorable results had been obtained after a moderate use of the bicycle, and certain tabetics had derived much benefit from its use.

M. Bouloumie presented the subject from a therapeutic point of view. He stated that he had recommended the bicycle to several gouty persons, who, after using it, had not suffered so much with stiffness in the knees and in the tibiotarsal articulations, which had become much stronger and more flexible. The general condition also had been benefited. In persons suffering with subacute nephritic colic from uric acid gravel, and presenting frequent and continual pains in the kidneys, without renal inflammation, the exercise seemed to facilitate the passage and expulsion of the calculus and to diminish the pains. In such cases the patients must be warned against excessive exercise, as any fatigue was extremely harmful. For persons affected with urinary and digestive disorders, principally liver troubles, an upright attitude in the saddle, with the body resting squarely upon the ischia, was absolutely indispensable. In this way all parts of the body would contribute to the maintenance of the equilibrium, the abdominal organs were not compressed, the action of the diaphragm was not hindered, and the circulation was not impeded at any point. This exercise, on the whole, said M. Bouloumie, was one which favored the development of the muscles and regulated the principal functions, and it could be recommended from a physiological, hygienic, and therapeutic point of view, subject to these conditions: 1. A good position in the saddle. 2. A proper saddle. 3. A moderate rate of speed.—N. Y. Med. Jour.

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